SESSION 5

INTEGRATIVES APPROACHES

O15 An integrative approach to control potato soil borne diseases
Karima Bouchek-Mechiche (inov3pt/INRAE-IGEPP, France)

O16 Impact of tillage on soil biological quality and potato diseases in an agroecological potato production system
Alexander Kröner (inov3pt/INRAE-IGEPP, France)

O18 Holland Innovative Potato Building Block 3: Mining for novel disease resistance in the Solanum germplasm
Jack Vossen (WUR, The Netherlands)

P22 From soil biological fertility to potato health. How to combine agroecological farming practices in a field experiment ?
Claudine Pasco (INRAE-IGEPP, France)

P23 From soil biological fertility to potato health. How to assess soil biological quality ?
Alexander Kröner (inov3pt/INRAE-IGEPP, France)

P24 Design, experimentation and evaluation of an agroecological cropping system for seed potato production
Mathilde Libert (Comité Nord Plants de Pommes de Terre)

An integrative approach to control potato soil borne diseases

Celia Cholez & Karima Bouchek-Mechiche

EAPR Pathology and Pests Section Meeting, 3-6 September 2023, Arras (France)

Presentation outline

- Context and goals
- Methodology aproach
- Some examples of the outputs of the study
- Conclusion & discussion

Context and goals

Introduction

Context

1. Scientific studies rarely include the multiplicity of pathogens, almost are single-pathogen
2. Control strategies are pathogen-specific

The goals of this study

1. To develop an integrated approach to control several pathogens together on potato crop
2. To move from a mono-pathogenic to a multi-pathogenic approach

Methodology Approach

Diseases involved in the study

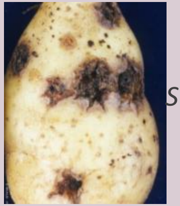
Fungi

Black scurf
R. Solani
RS

Silver scurf
H. Solani
HS

Black dot
C. Coccods
CC

Bacteria



Common scab
Streptomyces spp.
SC

Netted scab
S. Reticuliscabiei
SN

Protist

Powdery scab
S. Subterranea
SSS

Oomycete

Leak
Pythium spp.
Puu

General approach

I. Survey of existing knowledge for each disease
(pathogen life cycle and available control methods)
Constitution of an extensive data bases

II. Gathering diseases into groups according to their biological traits

III. Identification of common control methods

IV. Setting up a multi-pathogen control strategies

Outputs of the study

Some examples

Results

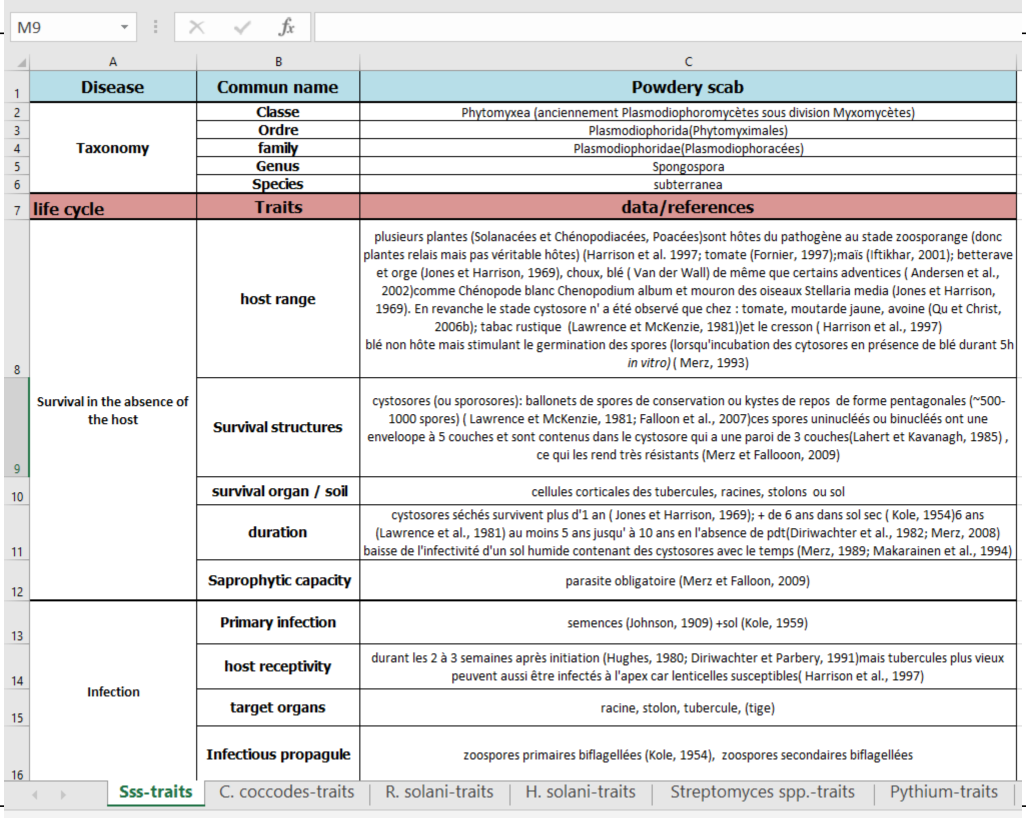
I. Survey of existing knowledge for each disease
(pathogen life cycle and available control methods)
Constitution of an extensive data bases

II. Gathering diseases into groups according to their biological traits

III. Identification of common control methods

IV. Setting up a pluri-specific control strategies

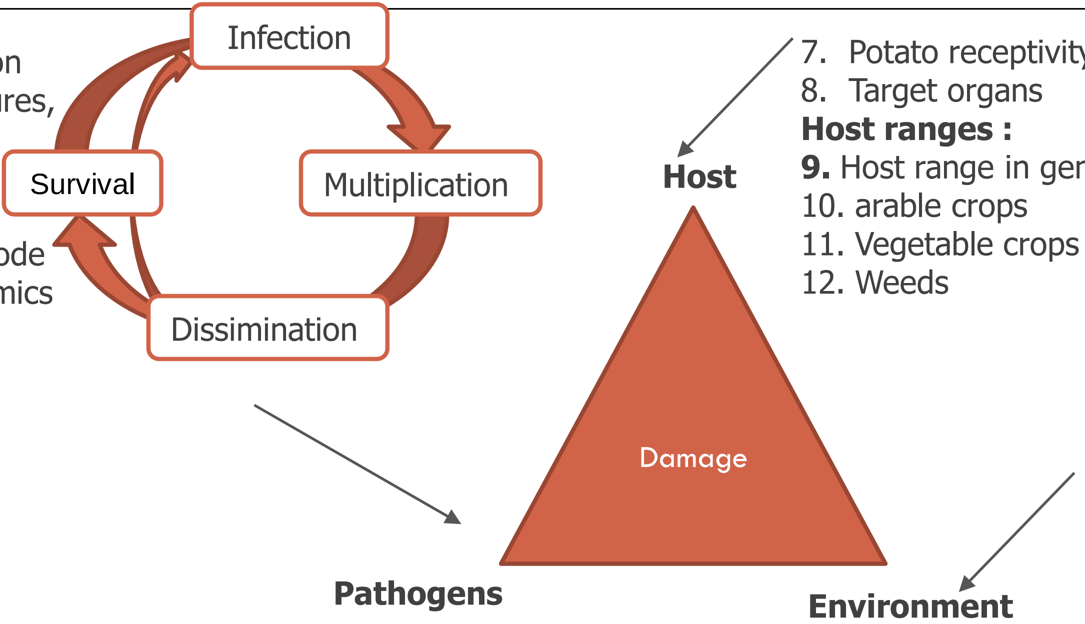
Setting up extensive database on pathogen/host/environment



Disease	**Commun name**	**Powdery scab**
Taxonomy	**Classe**	Phytomyxea (anciennement Plasmodiophoromycètes sous division Myxomycètes)
	Ordre	Plasmodiophorida(Phytomyximales)
	family	Plasmodiophoridae(Plasmodiophoracées)
	Genus	Spongospora
	Species	subterranea
life cycle	**Traits**	**data/references**
Survival in the absence of the host	**host range**	plusieurs plantes (Solanacées et Chénopodiacées, Poacées)sont hôtes du pathogène au stade zoosporange (donc plantes relais mais pas véritable hôtes) (Harrison et al. 1997; tomate (Fornier, 1997);maïs (Iftikhar, 2001); betterave et orge (Jones et Harrison, 1969), choux, blé (Van der Wall) de même que certains adventices (Andersen et al., 2002)comme Chénopode blanc Chenopodium album et mouron des oiseaux Stellaria media (Jones et Harrison, 1969). En revanche le stade cystosore n' a été observé que chez : tomate, moutarde jaune, avoine (Qu et Christ, 2006b); tabac rustique (Lawrence et McKenzie, 1981))et le cresson (Harrison et al., 1997) blé non hôte mais stimulant le germination des spores (lorsqu'incubation des cytosores en présence de blé durant 5h *in vitro)* (Merz, 1993)
	Survival structures	cystosores (ou sporosores): ballonets de spores de conservation ou kystes de repos de forme pentagonales (~500-1000 spores) (Lawrence et McKenzie, 1981; Falloon et al., 2007)ces spores uninucléés ou binucléés ont une enveloope à 5 couches et sont contenus dans le cystosore qui a une paroi de 3 couches(Lahert et Kavanagh, 1985) , ce qui les rend très résistants (Merz et Fallooon, 2009)
	survival organ / soil	cellules corticales des tubercules, racines, stolons ou sol
	duration	cystosores séchés survivent plus d'1 an (Jones et Harrison, 1969); + de 6 ans dans sol sec (Kole, 1954)6 ans (Lawrence et al., 1981) au moins 5 ans jusqu' à 10 ans en l'absence de pdt(Diriwachter et al., 1982; Merz, 2008) baisse de l'infectivité d'un sol humide contenant des cystosores avec le temps (Merz, 1989; Makarainen et al., 1994)
	Saprophytic capacity	parasite obligatoire (Merz et Falloon, 2009)
Infection	**Primary infection**	semences (Johnson, 1909) +sol (Kole, 1959)
	host receptivity	durant les 2 à 3 semaines après initiation (Hughes, 1980; Diriwachter et Parbery, 1991)mais tubercules plus vieux peuvent aussi être infectés à l'apex car lenticelles susceptibles(Harrison et al., 1997)
	target organs	racine, stolon, tubercule, (tige)
	Infectious propagule	zoospores primaires biflagellées (Kole, 1954), zoospores secondaires biflagellées

Data acquisition on the pathogens : selection on 16 traits

1. Survival duration
2. Survival structures,
3. Saprophytic capacity, etc.
4. Propagule type
5. Penetration mode
6. Epidemic dynamics



7. Potato receptivity
8. Target organs

Host ranges :

9. Host range in general

10. arable crops
11. Vegetable crops
12. Weeds

13. pH
14. Humidity
15. Inoculum sources
16. Evolution in storage

Selection of 16 traits

Results

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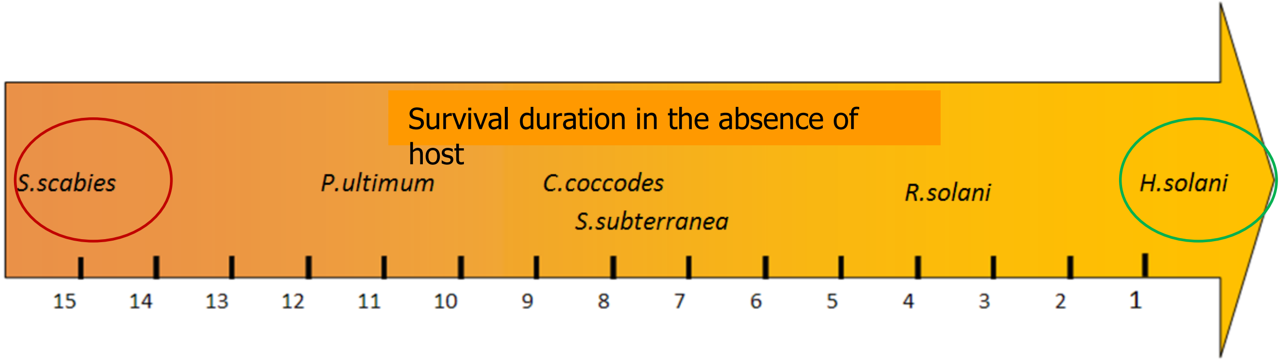
Grouping the pathogens according to their traits

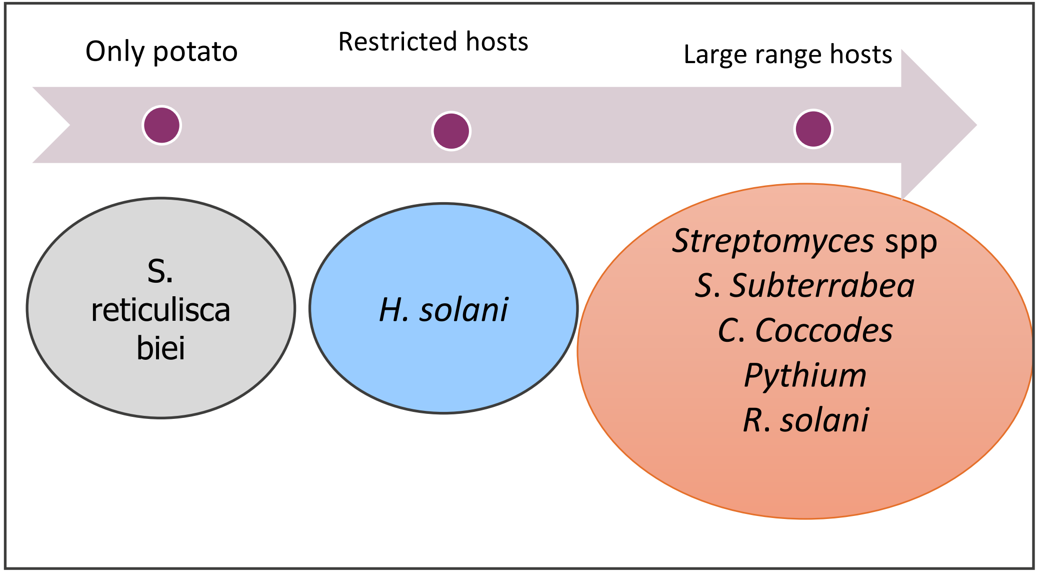
Pathogen traits

Survival duration


Survival duration in the absence of host

Grouping the pathogens according to their traits

Host range trait



Only potato

Restricted hosts

Large range hosts

S. reticulisca biei

H. solani

Streptomyces spp
S. Subterrabea
C. Coccodes
Pythium
R. solani

Grouping the pathogens according to their traits

Pathogen/host traits

Penetration way

Direct
R. solani
C. coccodes
H. solani

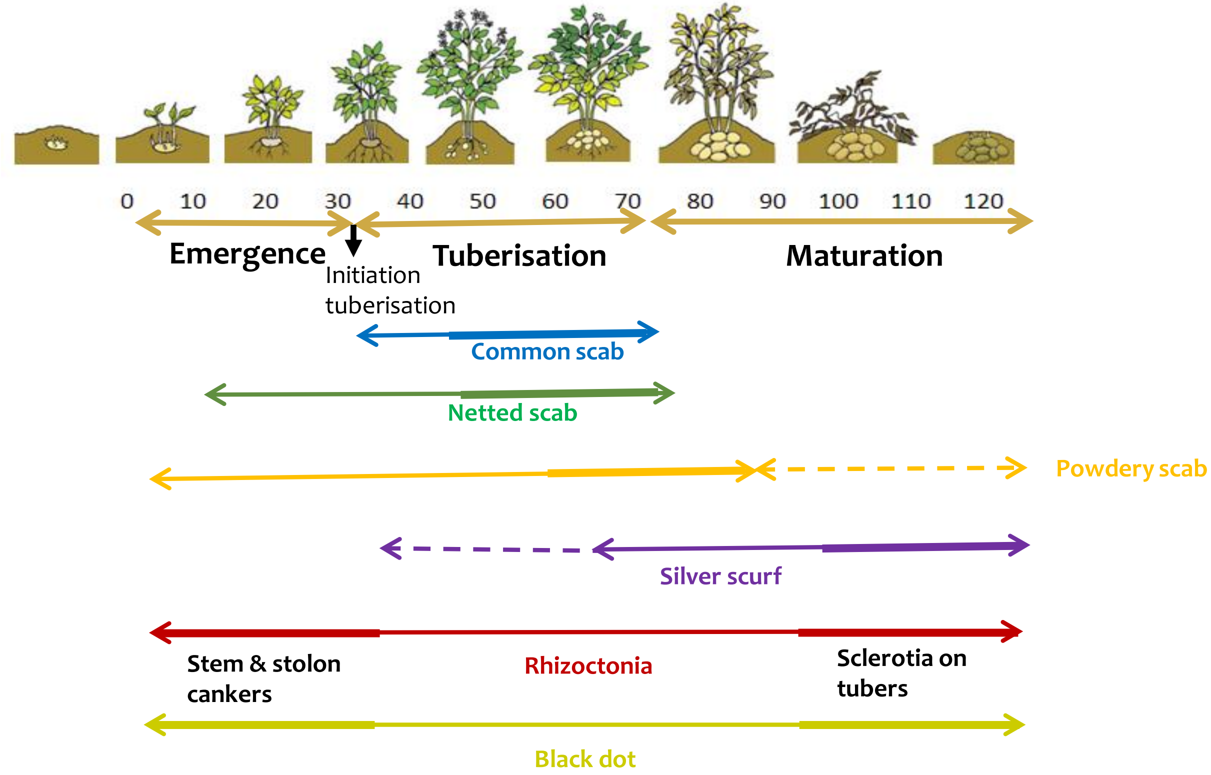
Lenticels
S. subterranea
S. scabies
S . reticuliscabiei

Wounds
P. ultimum

Grouping the pathogens according to their traits

host trait

Receptivity of potato plant at different stage of its development



Emergence

Initiation tuberisation

Tuberisation

Maturation

Common scab

Netted scab

Powdery scab

Silver scurf

Stem & stolon cankers

Rhizoctonia

Sclerotia on tubers

Black dot

Grouping the pathogens according to their traits

Disease development in storage

No development in storage

Rhizoctonia solani

Streptomyces scabies

Streptomyces reticuliscabiei

Development in storage

Colletotrichum coccodes

Helminthosporium solani

Pythium ultimum

Spongospora subterranea

General approach

I. Survey of existing knowledge for each disease
(pathogen life cycle and available control methods)
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II. Gathering diseases into groups according to their biological traits

III. Identification of common control methods

IV. Setting up a pluri-specific control strategies

Identification of common action methods

III. Building up synthetic tables: irrigation

	C. coccodes Black dot	*R. solani* Black scurf	*H. Solani* Silver scurf	*S. scabies* Common scab	*S. reticuliscabiei* Netted scab	*S. subterranea* Powedery scab	*P. lutimum* Leak
Early irrigation (from emergence to 4- 6 weeks after tuber initiation initiation	-	+	+	+	-	-	na
Late irrigation (during tuber maturation)	0	(-)	+	+	-	(-)	na
Irrigation durant tout le cycle de culture	-	na	+	+	-	-	na

+ : positive effect

0 : neutral effect

- : negative effect

na : non-available data

Identification of common action levers

III. Building up synthetic tables: host range

	Colletotrichum coccodes	Rhizoctonia solani	Helminthosporium solani	Streptomyces scabies	Streptomyces reticuliscabi	Spongospora subterranea	Pythium ultimum
Solanaceae Other than potato	+	+	+	-	-	+	-
Poasseae (Grasses)	-	+	-	+	-	+	+
Fabiaceae (legumes)	-	+	-	+	-	-	+
Brassica (Cruciferous)	+	+	-	+	-	+	+
Asteraceae	+	+	-	+	-	-	+
chenopodiaceaes	+	+	-	+	-	-	+
Apiaceae	-	+	-	+	-	-	+

Légende

+	Host
-	Non Host

General approach

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Data acquisition on control methods

5. Construction of toolboxes for a multipathogen control

Action on initial stock inoculum

Strategy aiming destruction or reduction of initial inoculum stock

Storage Management

Strategy aiming to avoid multiplication and dissemination of pathogens in stores

Avoiding strategy

Avoid to match the infectious phase of the pathogen with the susceptible period of the plants

Attenuation in culture

Minimizing the damage when the plant and the pathogen meet

Setting up a multi-pathogens control strategies

III. Building up 4 toolboxes

Action on initial
inoculun
Strategy aiming des
reduction of initial in

Avoiding stra
Avoid to match the
phase of the pathog
susceptible period c

Control
method 1

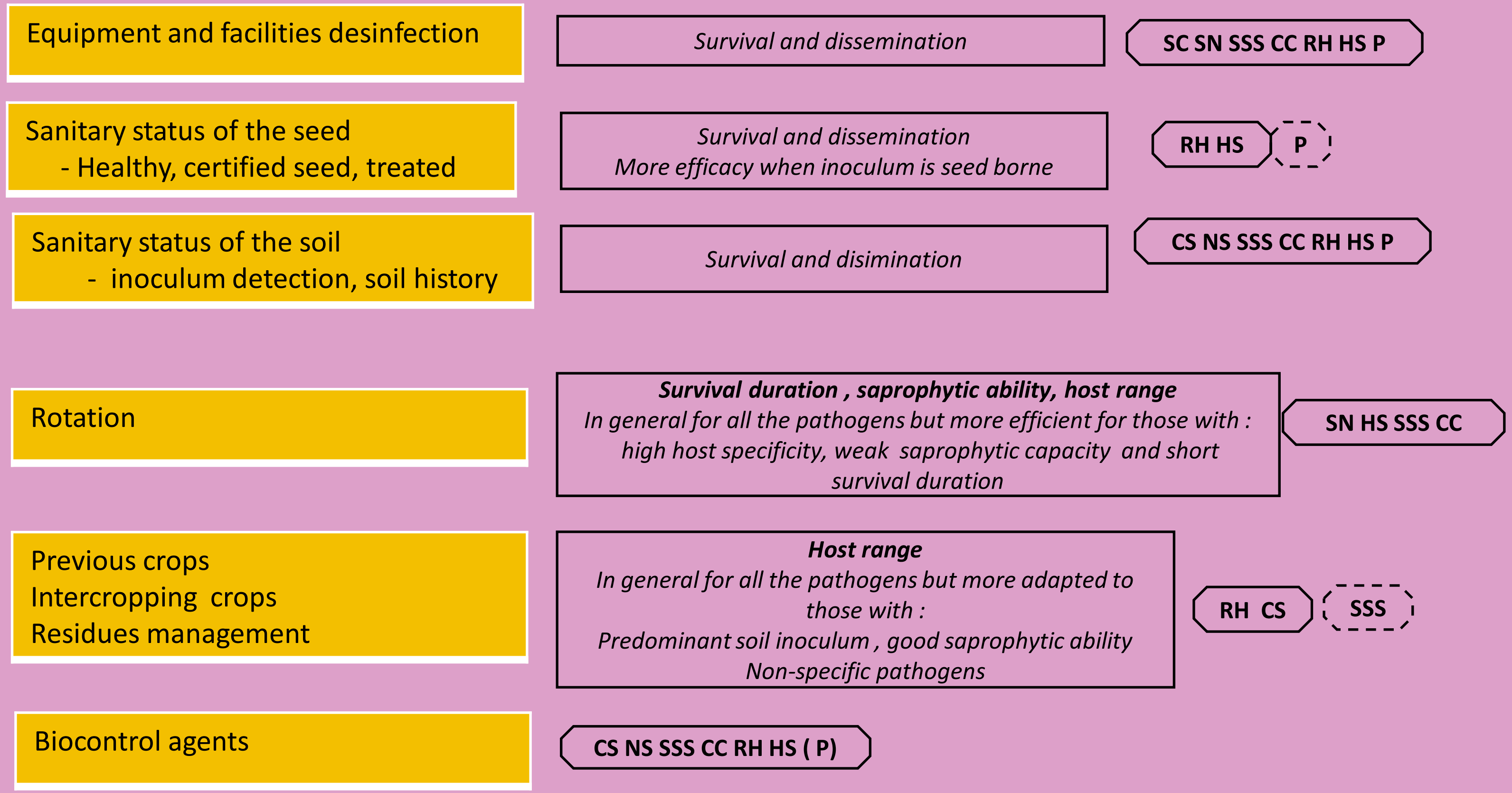
⋮

Control
method n

Tageted trait

Targeted diseases

Action on initial stock inoculum



Equipment and facilities desinfection

Survival and dissemination

SC SN SSS CC RH HS P

Sanitary status of the seed
- Healthy, certified seed, treated

Survival and dissemination
More efficacy when inoculum is seed borne

RH HS **P**

Sanitary status of the soil
- inoculum detection, soil history

Survival and disimination

CS NS SSS CC RH HS P

Rotation

Survival duration , saprophytic ability, host range
In general for all the pathogens but more efficient for those with : high host specificity, weak saprophytic capacity and short survival duration

SN HS SSS CC

Previous crops
Intercropping crops
Residues management

Host range
In general for all the pathogens but more adapted to those with :
Predominant soil inoculum , good saprophytic ability
Non-specific pathogens

RH CS **SSS**

Biocontrol agents

CS NS SSS CC RH HS (P)

Action on initial stock inoculum

Conclusion & perspectives

Some examples

Conclusion

Our study has two purposes

- ✓ **Formalisation of knowledge** on potato soilborne diseases & Highlighting the literature gaps
  - The tools and documents generated by this work could be evolved by new data
- ✓ **Set up a methodology approach:**
  - * to gather pathogens according to their traits
  - * to understand the mode of action of the control method
  - * to set up control strategies based on methods combination targeting a group of pathogens

Perspectives

The next steps

To design innovative cropping systems minimising the risk of important pathogens :

- The data bases should be completed by other diseases/pests late blight, black leg, wireworm, viruses, etc…
- Apply this approach to the conception of alternative strategies in concrete potato production systems
- Experiment these strategies to confirm their performances against pathogens and to create references on combined control methods
- Contribution of modelisation to simulate the performance for a large control strategies and to select only some to be experimented

An integrative approach to control potato soil borne diseases

Celia Cholez & Karima Bouchek-Mechiche

Thank you for your attention!

Impact of tillage on soil biological quality and potato diseases in an agroecological potato production system

Puech C., Kröner A., Pasco C., Beduneau F., Maestrali M., Hervet M., Andrivon D., Bouchek-Mechiche K.

Presentation outline

1 **Introduction**
- Study context & objectives

2 **Methodology**
- Experimental site and design
- Crop protocol/Climatic conditions
- Measurements and observations

3 **Results**
- Soil biological quality
- Potato diseases
- Yield

4 **Take-Home**
- Results summary
- Conclusions
- Perspectives

1 - Introduction

Study context & objectives

Life on earth (incl. potato production) depends on healthy/living soils

Soil biodiversity : a variety of organisms spending a part or their entire life in the soil.

earthworms
carabid beetles

spiders
springtails

nematodes

bacteria
fungi

Biological Soil Functions ⇨ **Ecosystem services**

Examples :

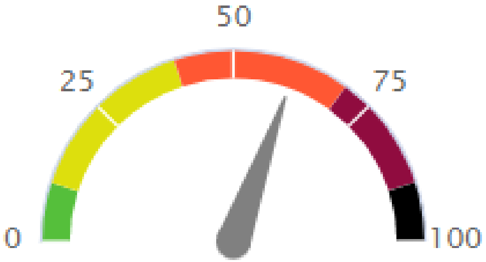
Element cycling → Biomass production

Population regulation → Pest and disease control

Soil threats (i.e. loss of soil biodiversity) disrupt soil functions for biomass production and disease/pest control !

For further reading : Bunemann, E. K. et al. (2018). Soil quality - A critical review. Soil Biology & Biochemistry, 120, 105-125.

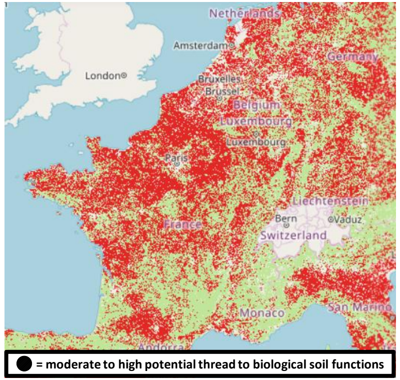
Soil degradation in the EU



61 % of land

is likely to be affected by one

or more soil degradation processes.



● = moderate to high potential thread to biological soil functions

Loss of soil biodiversity

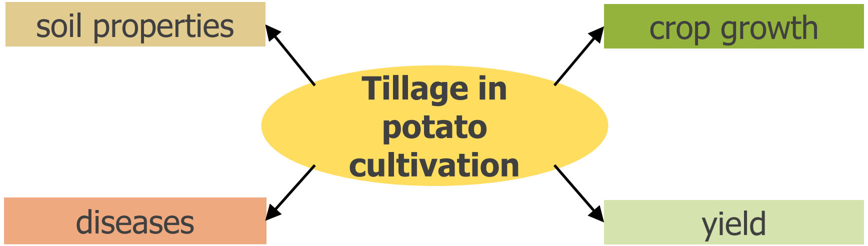
is a major soil degradation process, overlapping

with low **soil carbon stock** and **water erosion.**

Source : EU Soil Health Dashboard (11/05/2023) at https://esdac.jrc.ec.europa.eu/esdacviewer/euso-dashboard/

Tillage impact on potato production and soil

Tillage practices (e.g. moldboard plowing, chisel plowing, minimum tillage) affect potato production in multiple ways[1] :



soil properties

crop growth

Tillage in potato cultivation

diseases

yield

→ **Purposeful tillage is a strong lever for sustained potato production.**

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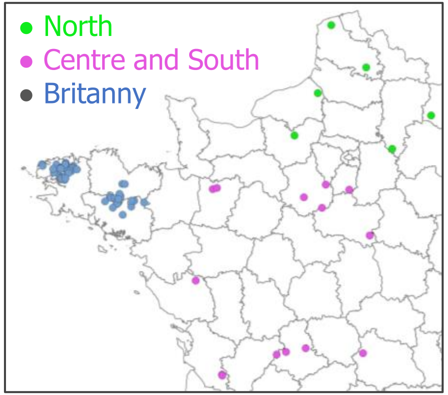
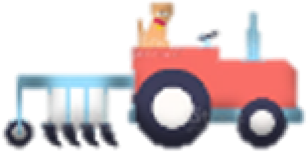
[1] Djaman, K. et al. (2022). Tillage Practices in Potato (*Solanum tuberosum* L.) Production : A Review. American Journal of Potato Research, 99(1), 1-12.

Tillage practices of potato growers in France

A survey[1] among 75 seed potato growers in France revealed :

Intensive tillage (i.e. ploughing, sieving of soil) is the dominant practice[1]





However, ***reduced*** **tillage** is expected to be beneficial for soil health (e.g. soil biodiversity[2]).

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[1] Survey realised in 2020-2021 by the French Federation of Seed Potato Growers (FN3PT/inov3PT)

[2] Betancur-Corredor, B. et al. (2022). Reducing tillage intensity benefits the soil micro- and mesofauna in a global meta-analysis. European Journal of Soil Science, 73(6).

Objectives of this work

1. To set up a long-term, large-scale experiment in an agroecological potato production system to **study the effects of ploughless tillage** on:

   - soil biological quality (increased biological fertility expected)
   - soilborne diseases (better biological regulation expected)
   - potato yield (similar or better yield expected)

2. To **assess different indicators** in farming conditions for monitoring soil biodiversity in order to select the useful ones.

3. To acquire references and disseminate data to producers in order to **encourage tillage practice change**.

2 - Methodology

Experimental site and design

Crop protocol

Measurements and observations

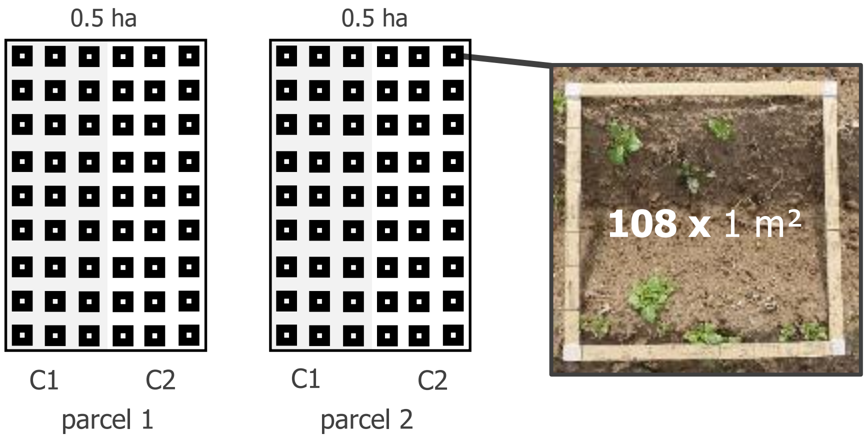
Climatic conditions

Experimental site

- Agroecological experimental site of the INRAE in Britanny (3 ha, France, Le Rheu), managed since 2018 with and without ploughing. Crop rotation includes **potato,** maize, wheat and overwinter cover crops.

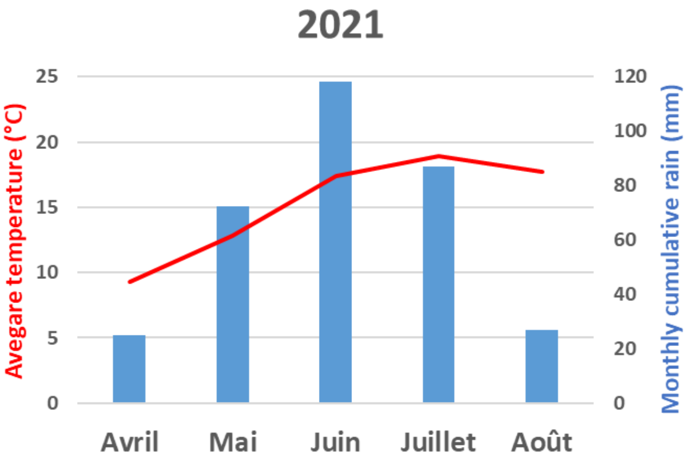
- Project period : 2021 – 2024 (at least).

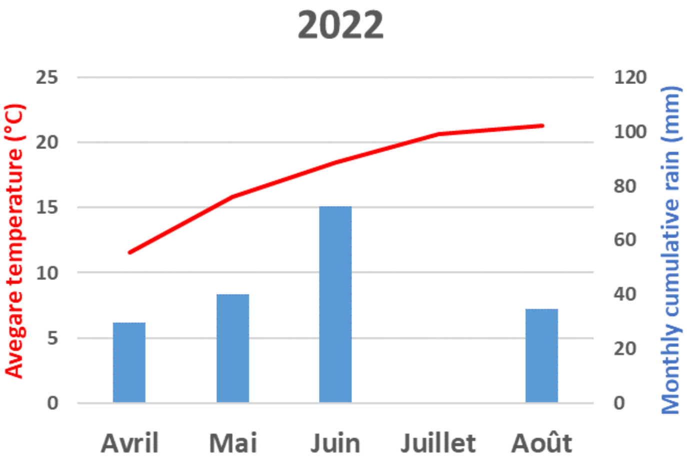
Experimental design



- Two nearby parcels (2 x 0.5 ha, ploughed or not ploughed)
- Two potato cultivars (encoded as C1 and C2), to discern potential cultivar specific behaviors
- Each of both parcels contains 54 defined plots (1 m^2) for sampling and observation.

Contrasting climatic conditions





- In contrast to 2021, the climate was markedly hot and dry in 2022.

Crop management

Period	Operation	
October – Mars	Overwinter cover crop	✓
Mars	Fertilization (organic and mineral)	✓
Mars – Avil	Basic tillage (cultivator and rotary tiller)	✓
	Ploughing	**optional**
Avril – Mai	Planting	✓
Mai	Weed control (tine harrow, hilling, manual removing of curly dock)	✓
Late June	Crop protection (potato beetle, SUCCESS 4 in case of need)	✓
Late July	Mechanical haulm killing	✓
Late August	Harvest	✓

Measurements and observations *(cf. posters)*

soil quality

- earthworms
- nematodes
- spiders & ground beetles
- decomposition of organic matter
- soil stability
- lab analyses

potato health

	on tubers	on stem/leaves
common scab	x	
silver scurf	x	
black dot	x	
black surf	x	x
virus diseases		x
early blight		x
black leg		x
Colorado potato beetle		x
wireworms	x	

Development and yield

- gross yield
- tuber diameter

- soil coverage
- canopy height
- senescence

3 - Results

Soil biological quality

Potato diseases

Yield

Measurements and observations

soil quality

earthworms

nematodes

spiders &
ground beetles

decomposition of
organic matter

soil stability

lab analyses

potato tuber health

common scab

silver scurf

black dot

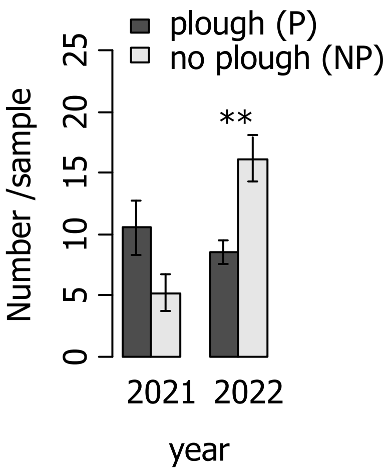
black scurf

potato yield

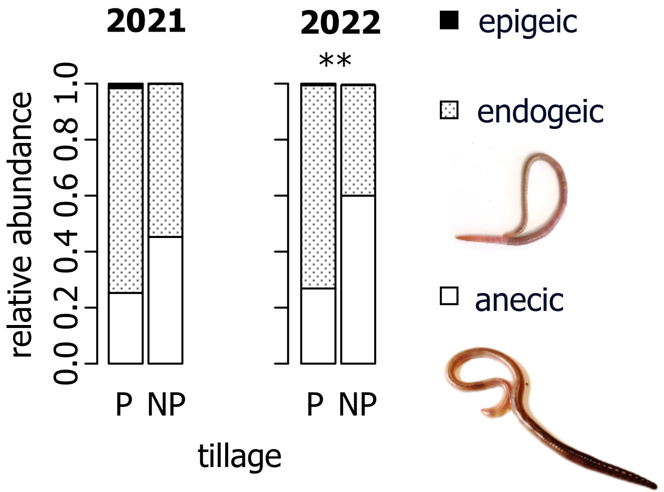
gross yield

Earthworms

In late February, earthworms are extracted from soil samples and attributed to functionals groups.



Abundance

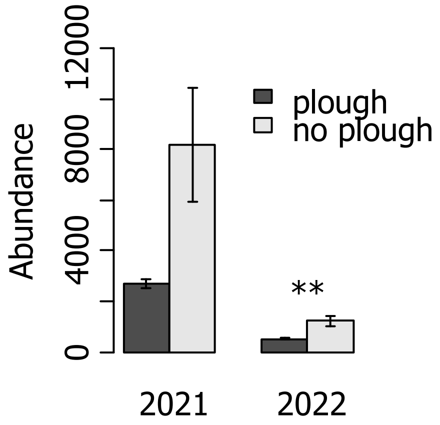


Functional groups

Results were year specific, with significant effects of ploughless tillage in 2022 : total abundance was increased, with a higher proportion of anecic earthworms.

Nematodes

In early July, nematodes were separated from soil samples by the Oostenbrink method. Abundance was determined by stereo microscopical counting.

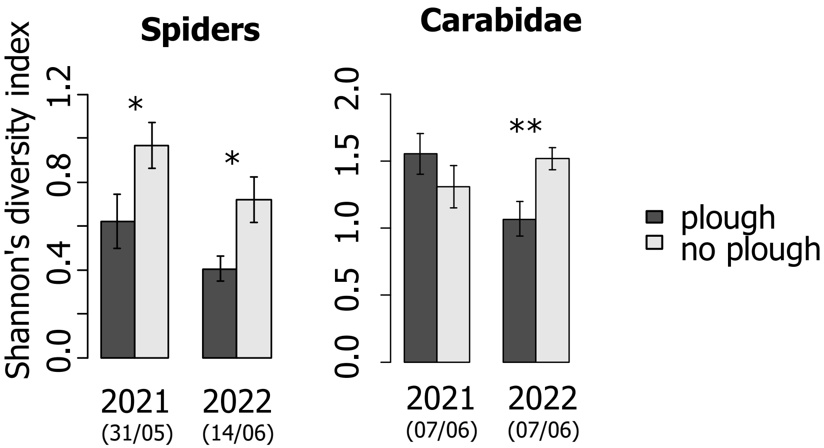


Nematodes in a 300g soil sample

Abundance was increased in no plough.
Heigh effect of the year on global abundance.

Barber pitfall trap

A Barber ground trap to catch arthropods crawling on the soil surface.

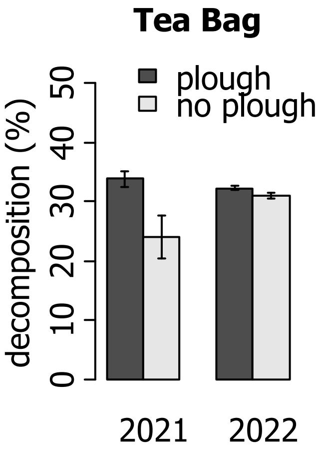


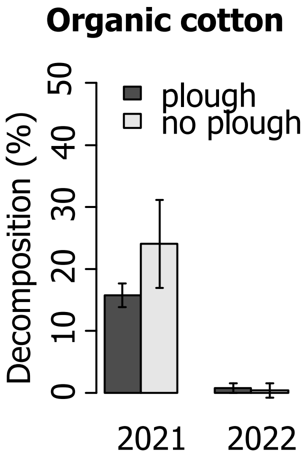
Diversity of **spiders** was the highest in the ploughless cultivated plot.
Diversity of **ground beetles** was not consistently increased in ploughless cultivated plot.

N.B. : results shown have been selected for significancy from a larger set of experimental data.

Decomposition of organic matter (field tests)

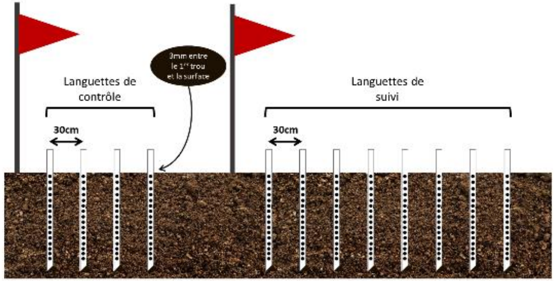
During July/August (7 weeks), buried tea bags and underpants were exposed to decomposition
by soil detrivores, and the state of decomposition was calculated.



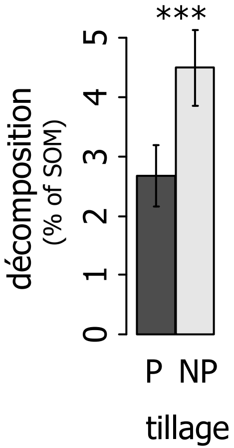


Neither test did clearly show-up potential differences in biological soil activity between tillage practices.
Organic cotton did barely decompose in 2022, but Tea Bag results were rather similar in both years.

Decomposition of organic matter (Bait Lamina, 2022)



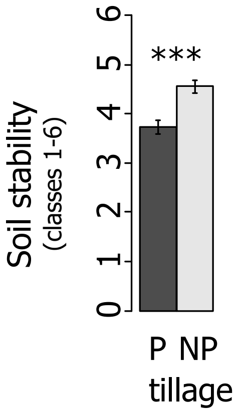
control **test**



Decomposition rate of organic matter was significantly increased in the unploughed plot.

Soil structural stability (2022)

Soil Stability Test Kit
(www.forestry-suppliers.com)

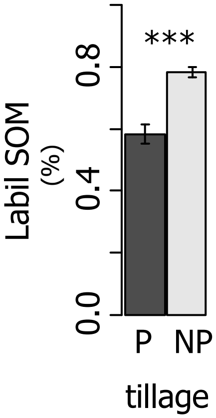


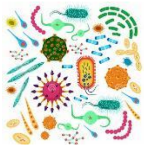
6 = excellent
1 = bad

Soil stability even better without ploughing.

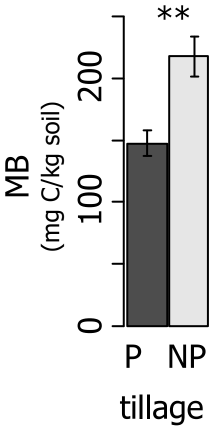
Biological laboratory soil analysis (2022)

Labile soil organic matter (SOM)





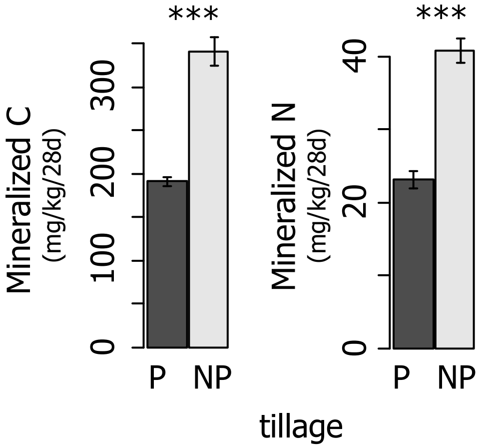
Microbial Biomass (MB)



Mineralization speed

carbon (C)

nitrogen (N)



Analyses by Celesta lab

No plough increases :

- Labile soil organic matter
- Microbial biomass
- Mineralization speed

Measurements and observations

soil quality

- earthworms
- nematodes
- spiders & ground beetles
- decomposition of organic matter
- soil stability
- lab analyses

potato tuber health

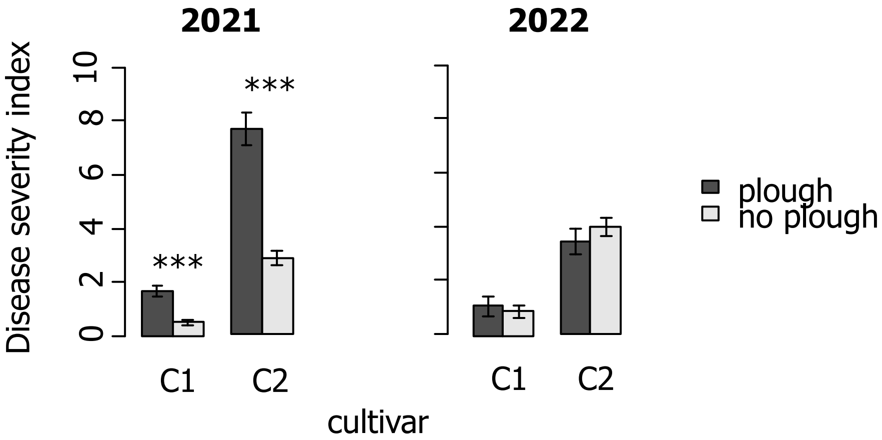
- common scab
- silver scurf
- black dot
- black scurf

potato yield

- gross yield

Black scurf severity

Potato tubers after harvest covered by black sclerotia.

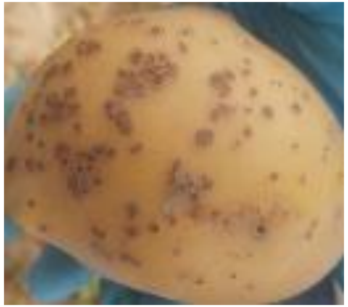


Disease severity on seed tubers:	0.4	1.8	0.7	3.9

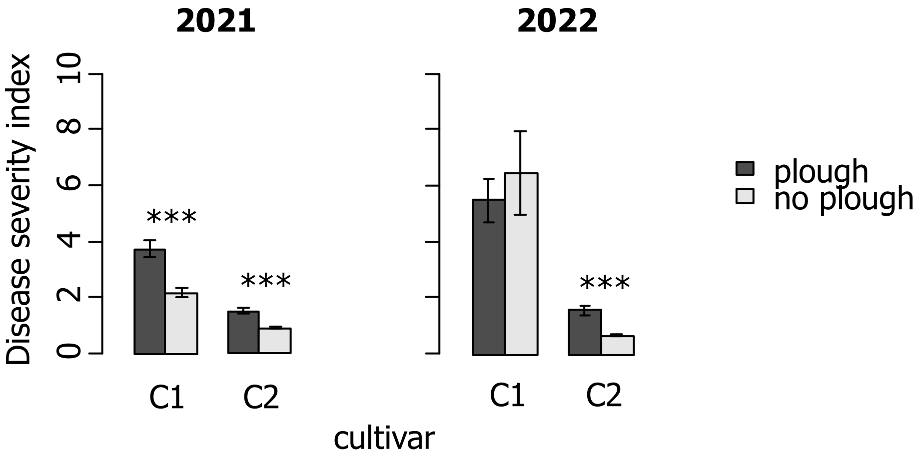
Ploughless cultivation clearly reduced severity of black scurf on harvested tubers, but only in 2021.
The severity of the disease varied greatly and in accordance with the initial inoculum on seed tubers.*

* In 2022, the absence of *Rhizoctonia solani* in the soil before planting has been confirmed by qPCR

Common scab severity



Potato tubers after harvest covered with scabby lesions.

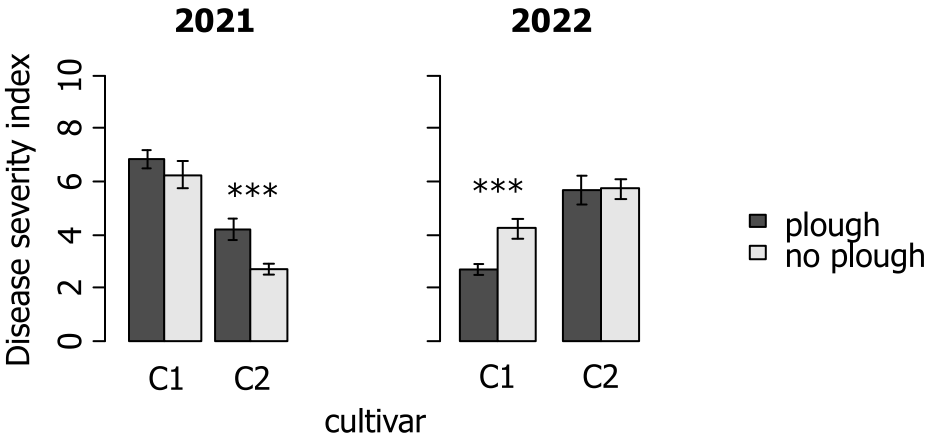


Disease severity on seed tubers :	1.5	5.6	0.8	0.0

Ploughless cultivation reduced severity of common scab.

Silver scurf severity

Potato tubers after storage covered with silvery patches.

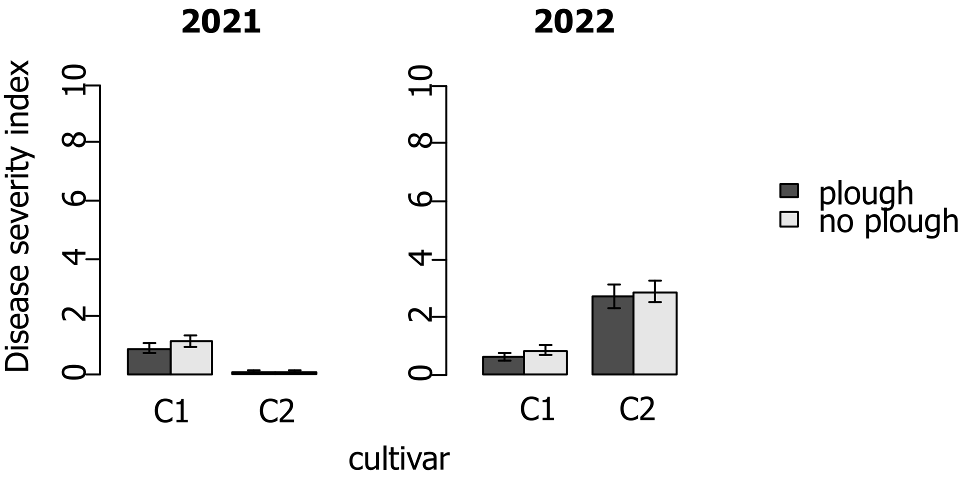


Disease severity on seed tubers	17.8	2.5	6.3	5.6

The effect of ploughless cultivation on silver scurf severity was quite inconsistent.

Black dot severity

Potato tubers after storage covered with small black, dot-like structures (sclerotia)



Disease severity on seed tubers	not assessed	2.7	1.3

Ploughless cultivation had no effect of black dot severity.

Measurements and observations

soil quality

earthworms

nematodes

spiders &
ground beetles

decomposition of
organic matter

soil stability

lab analyses

potato tuber health

common scab

silver scurf

black dot

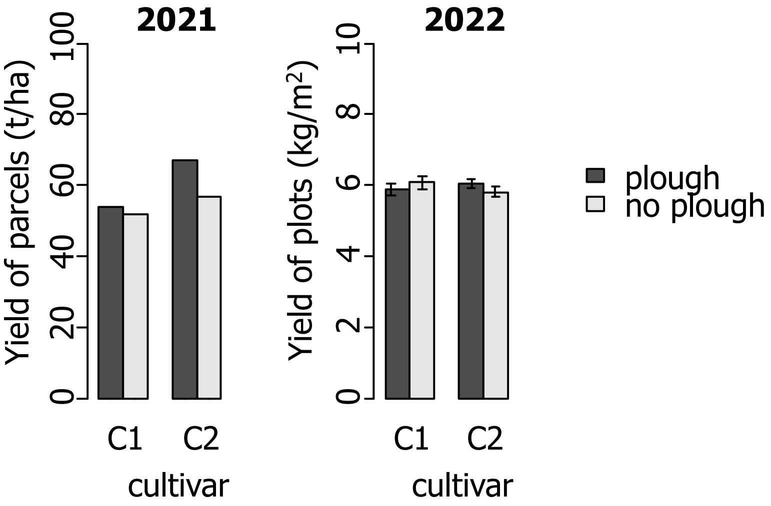
black scurf

potato yield

gross yield

Gross yield

In late August, gross yield was assessed by mechanized harvest of the entire plots (2021, as pictured above) or by manual harvest of sampling plots (2022).

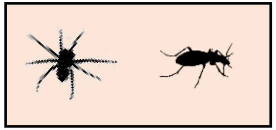


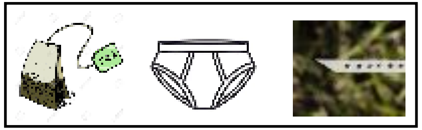
Yield was similar among treatments, and on a par with potato producers.

4 – Take Home

Results summary
Conclusions
Perspectives

Impact of ploughless tillage : soil biological fertility





Worms Nematodes
(abundance)

Spiders Beetles
(diversity)

Decomposition of SOM
(activity)

Soil stability

Lab analysis

2022	🟢	🟢	🟢	🟢	○	○	🟢	🟢	🟢
2021	○	🟢	🟢	🔴	○	○			

🟢 positive 🔴 negative ○ no effect

Ploughless tillage was mostly beneficial in terms of abundance and diversity.
Indictors for biological activity were less conclusive and need further investigation.

Impact of ploughless tillage : potato tuber health

disease severity

- 🟢 decrease
- 🔴 increase
- ○ no effect

Black scurf

Common scab

Silver scurf

Black dot

	Black scurf		**Common scab**		**Silver scurf**		**Black dot**	
	C1	C2	C1	C2	C1	C2	C1	C2
2022	○	○	○	🟢	🔴	○	○	○
2021	🟢	🟢	🟢	🟢	○	🟢	○	○

Ploughless tillage was mostly beneficial or at least neutral, in regard to potato tuber health.
It was less beneficial in 2022 than in 2021 and to some extent cultivar-specific.

Conclusions

So did ploughless tillage live up (so far) to our expectations ?

- 😃 **Increased soil biological quality.**
- 😃 **Similar yield**
- 🙂 **Better biological regulation of soilborne diseases, at least in some instances.**

Perspectives

- Results from 2023 (partly acquired) and observations scheduled for 2024 are intended to challenge theses conclusions in regard to year specific (climatic) conditions.

- Beyond the focus of this presentation on tillage and its effects on soil biodiversity, additional management levers will be combined and assessed (i.e. choice of potato cultivars).

- On a longer term, we hope to provide references for producers and valuable hints to decision makers on how to future-proof sustained potato production.

Staff Members & Support

Camille Puech

Alexander Kröner (2023)

Marie Hervet

Karima Bouchek-Mechiche

C. Pasco

D. Andrivon

Our special gratitude to J. Pirault, M. Gernigon and his collegues from the INRAE experimental unit Le Rheu for their field work services. A big thank to our collegues for their support in monitoring.

Trainees

Maëlle Maestrali (2021)

François Beduneau (2022)

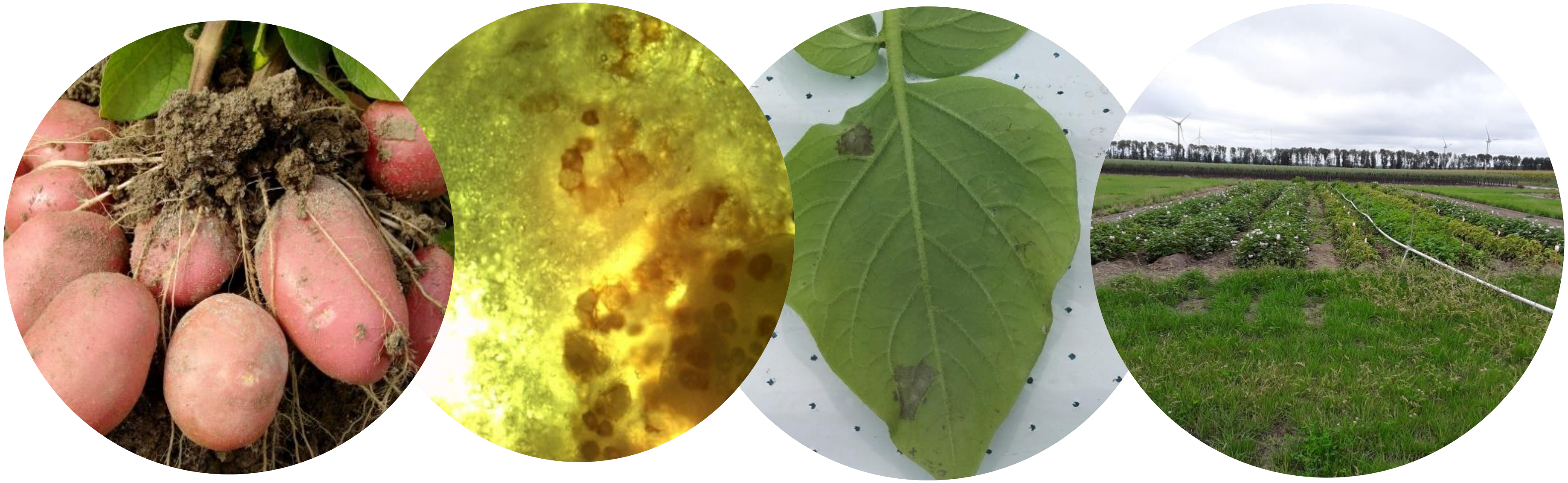
Holland Innovative Potato Building Block 3;

Mining for novel disease resistance in the Solanum germplasm

Jack Vossen

EAPR section meeting, pathogens and pests

Arras, September 5th 2023



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Holland Innovative Potato (HIP)

- Organisation

Ministerie van Landbouw,
Natuur en Voedselkwaliteit

HIP
Holland Innovative Potato

- Research aims
  - Sustainable and circular potato production
    - Reduced pesticide usage
    - Less losses
    - Higher efficiency

Building block 3:
Resistance mining in Solanum species

Work packages:

- 3.1 Microbial diseases (Jack Vossen)
- 3.2 Nematodes (Misghina Goitom Teklu)
- 3.3 Insects (Lotte Caarls)
- 3.4 Nematodes/plant/soil interaction

	2018	2019	2020	2021	2022	2023	2024
BB 3.1	░	▒	▓	▓	▓	░	
BB 3.2			▓	▓	▓	▓	░
BB 3.3	░	▒	▓	▓	▓	░	
BB 3.4					░	▓	▒

Wild potato relatives:
PBR Solanum collection

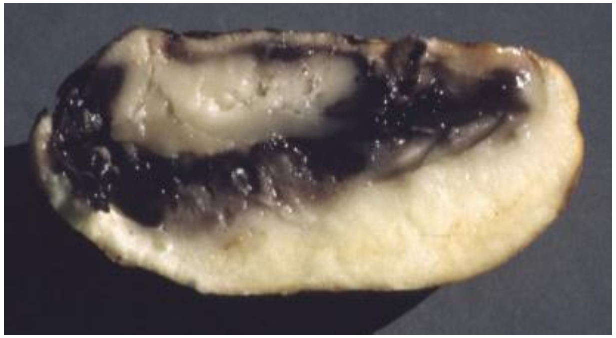
- WU&R-PBR: Umbrella, CBSG > Late blight resistance
- Currently: 800 genotypes; 300 accessions; 100 species


chc543-5

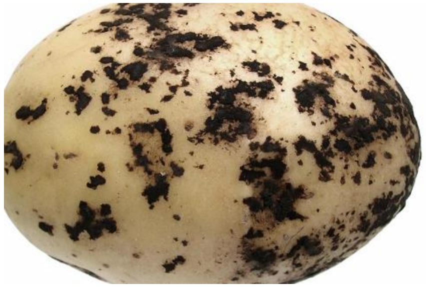

sto838-5

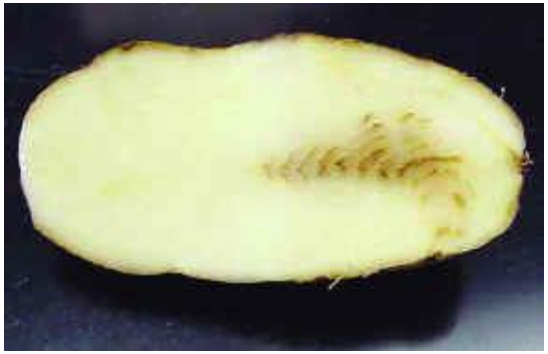

vnt367-1

WP 3.1: Microbes



Disease	Pathogens	Assay type
Soft rot, black leg	*Dickeya solani*	*Leaf inoculation*
	Pectobacterium brasiliensis	
Dry rot	*Fusarium solani*	*Stem inoculation*
	Fusarium sambucinum	
Common scab	*Streptomyces scabies*	*Agroinfiltration*
Black scab, stem canker	*Rhizoctonia solani*	*Agroinifiltration*
Viral spraing	PLRV	*Agroinfiltration*
	PMTV	*Agroinfiltration*





Summary of screening results

Pathogens	Assay type	Solanum genotypes screened in duplicate	Potentially resistant genotypes found
Dickeya solani	*Leaf inoculation*	*332*	*6*
Pectobacterium brasiliensis		*332*	*18*
Fusarium solani	*Stem inoculation*	*322*	*33*
Fusarium sambucinum		*322*	*30*
Streptomyces scabies	*Agroinfiltration*	*185*	*6*
Rhizoctonia solani	*Agroinifiltration*	*210*	*0*
PLRV	*Agroinfiltration*	*378*	*29*
PMTV	*Agroinfiltration*	*185*	*0*

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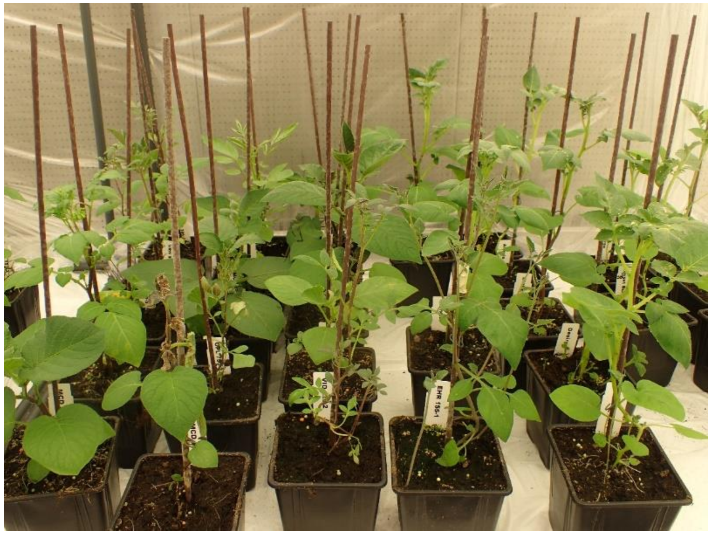
Screening for Dry Rot resistance

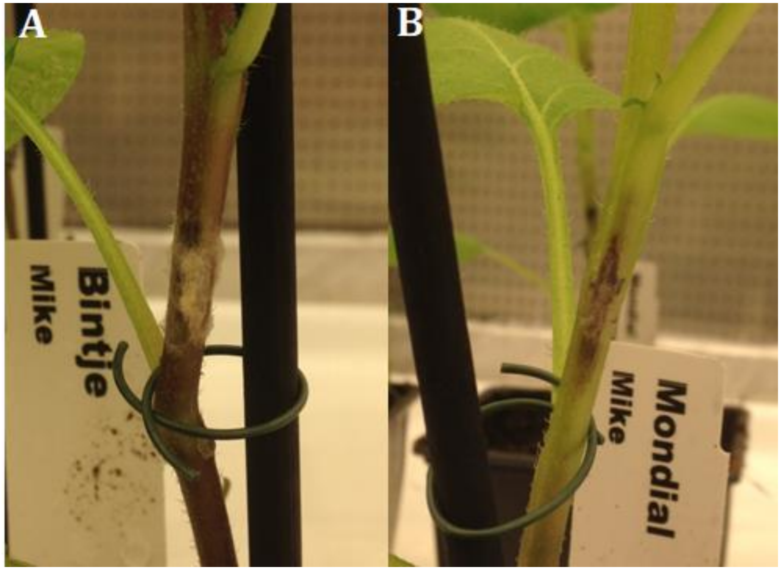
- In vitro plants > Potting soil > climate cell

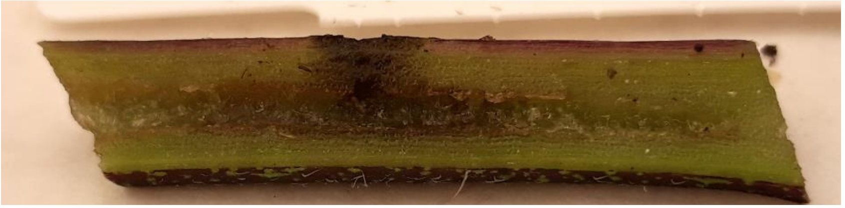


- Stem inoculation (wounding, 2000 macro-conidia per plant)

Fusarium sambucinum
Fusarium solani

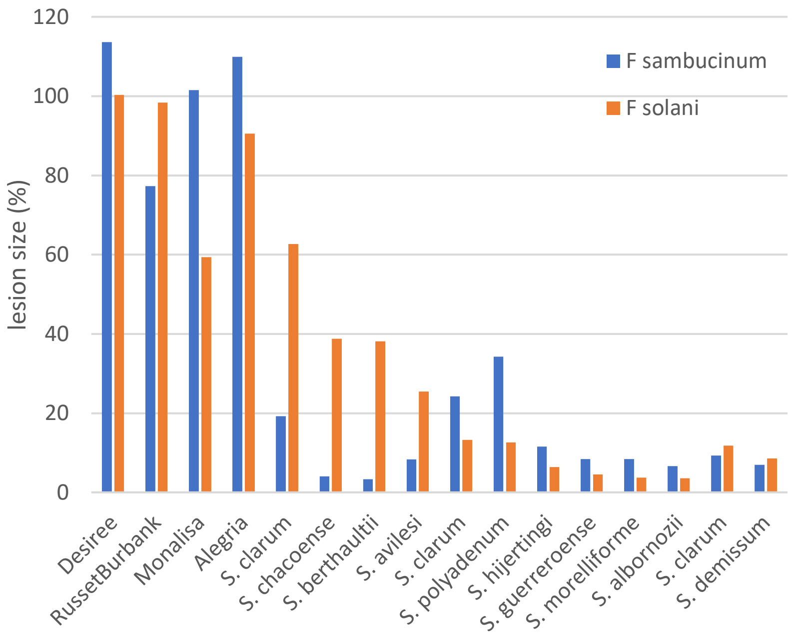
8 day post inoculation



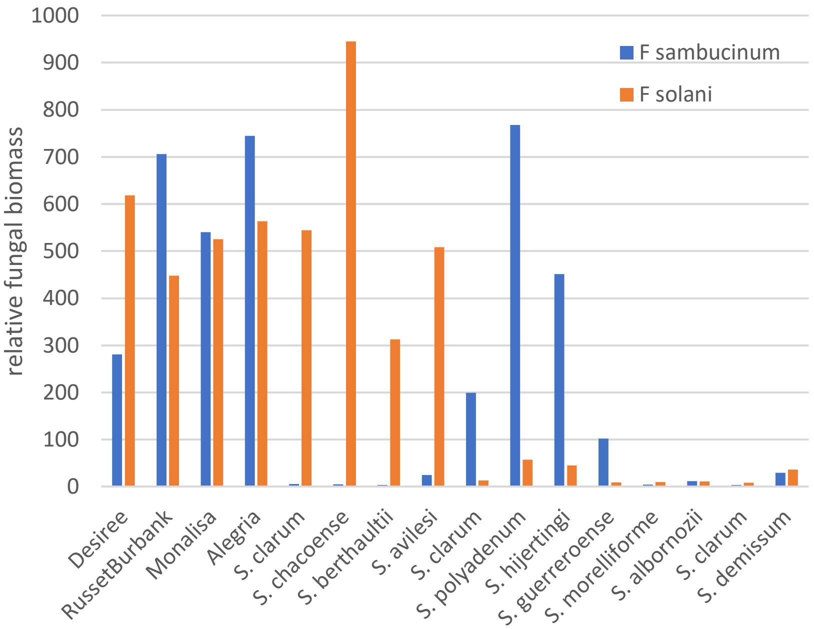


Selection of Fusarium resistant genotypes

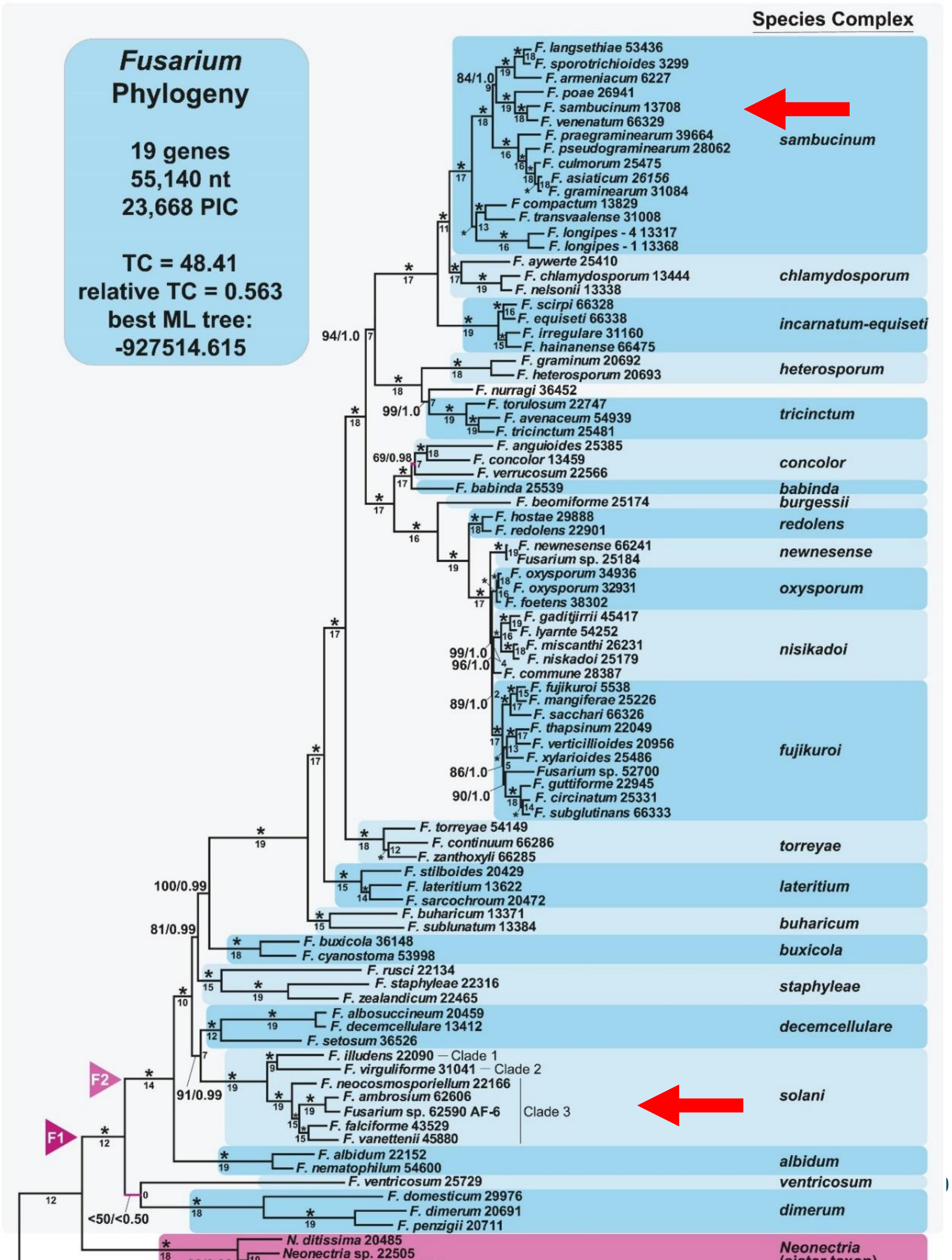
Lesion size measurement



Fusarium Q-PCR



Diversity in the genus Fusarium



Source: Geiser et al. (2021)
Phytopathology 111:1064-1079

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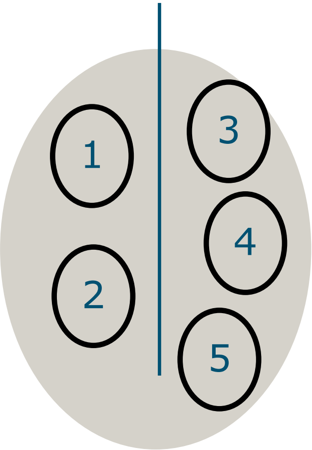
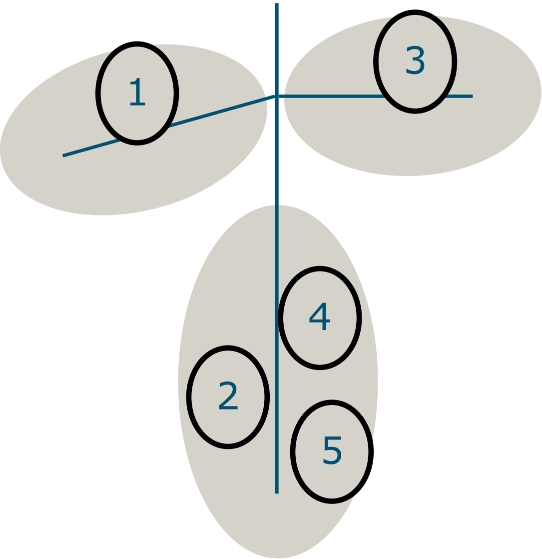
Screening for effector responses

- 150 agrocompetent Solanum genotypes
- Five *S. scabies* effectors
- Nine PMTV constructs
- Four *Rhizoctonia solani* effectors
- PLRV viral replicon

38 PLRV responsive genotypes found



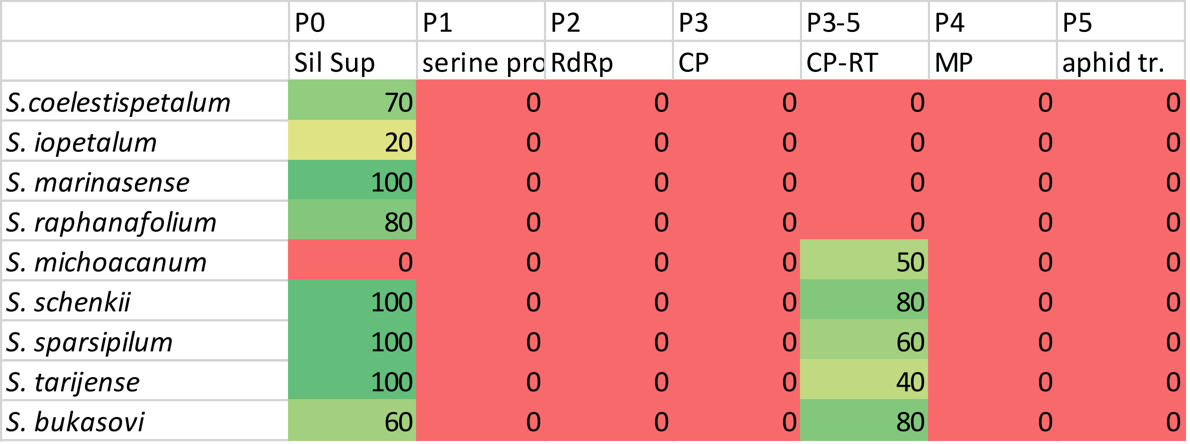
S. bukasovi



S. bukasovi

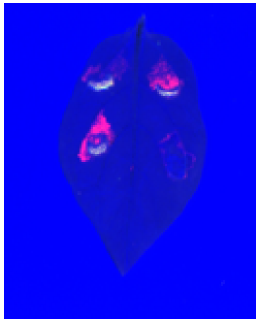
1: PLRV
2: PLRV
3: R3b
4: RFP
5: R3b+Avr3b

Response to individual PLRV genes

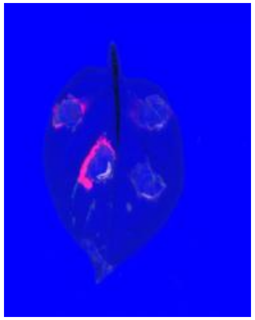


	P0	P1	P2	P3	P3-5	P4	P5
	Sil Sup	serine pro	RdRp	CP	CP-RT	MP	aphid tr.
S.coelestispetalum	70	0	0	0	0	0	0
S. iopetalum	20	0	0	0	0	0	0
S. marinasense	100	0	0	0	0	0	0
S. raphanafolium	80	0	0	0	0	0	0
S. michoacanum	0	0	0	0	50	0	0
S. schenkii	100	0	0	0	80	0	0
S. sparsipilum	100	0	0	0	60	0	0
S. tarijense	100	0	0	0	40	0	0
S. bukasovi	60	0	0	0	80	0	0

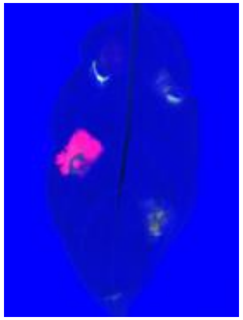
Segregation of HR response in _S. bukasovi_*RH89-039-16 population



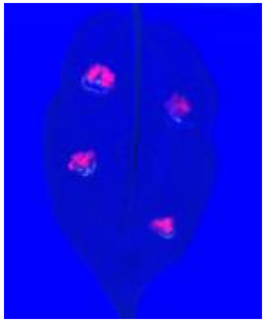
P0



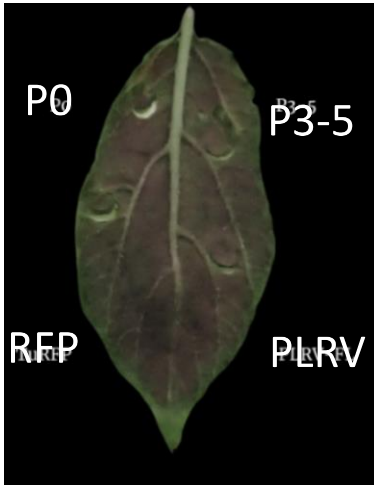
P3-5



P0 + P3-5 (both)



No response

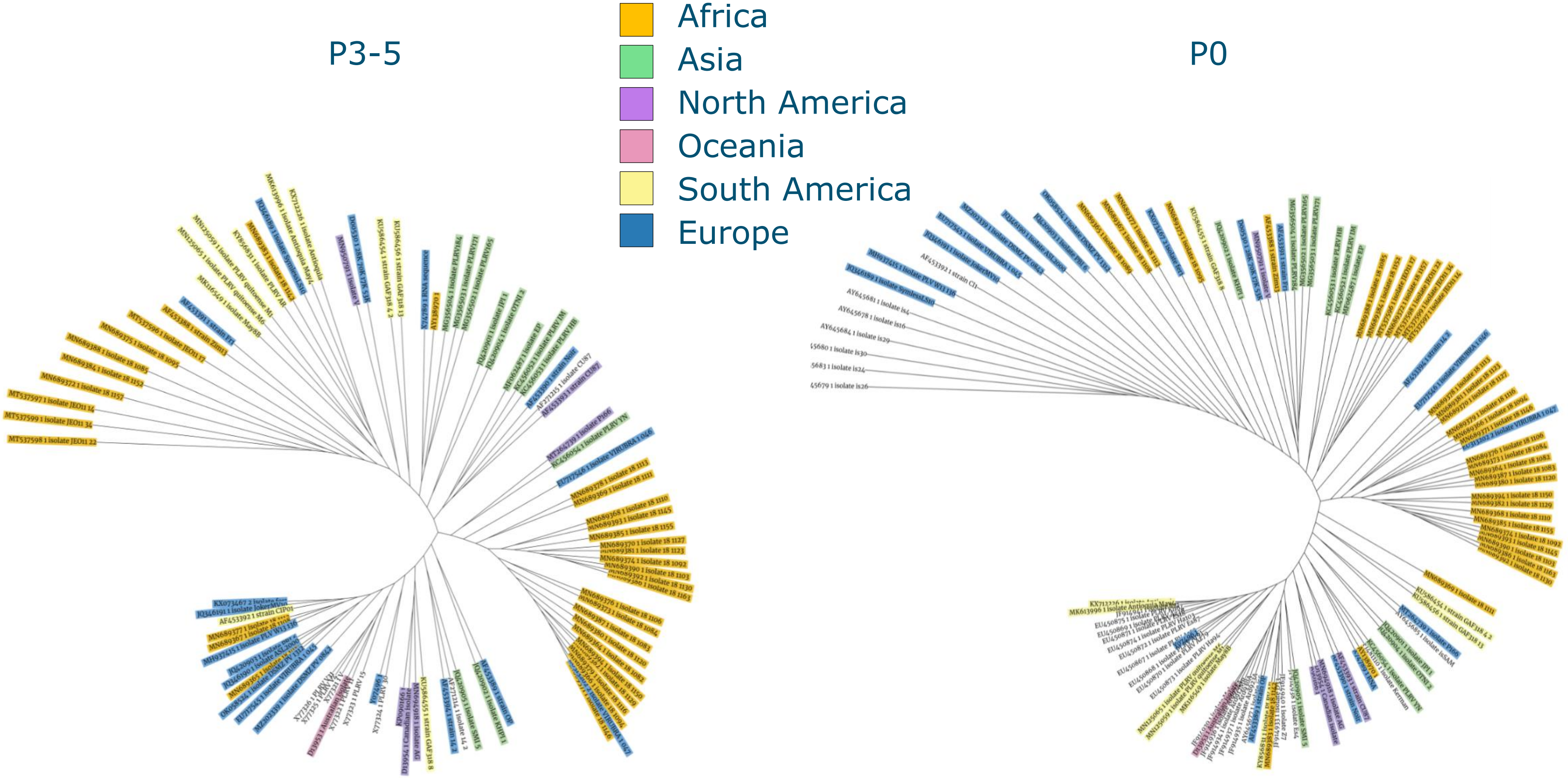


response	Nr of individuals
P0	12
P3-5	11
both	9
No response	16

Expected in case of two genes

1:1:1:1=P0:P3-5:both:NR

Sequence diversity among PLRV_P0 and PLRV_P3-5 proteins



Solanum species response to natural PLRV_P0 variants

	P0 E186	E186K	E186Q	E186T
S. iopetalum	100	100	15	15
S. marinasense	100	100	100	80
S. sparsipilum	100	0	50	100
S. tarijense	100	100	100	75
S. bukasovi	75	75	50	100

Conclusions and perspectives

- For 6 out of 8 pathogens potential resistance sources are found
- 2 examples about pathogen informed breeding
- Follow up research is needed
    - Validation of resistance in practice (field and tuber assays)
    - Genetic and molecular mechanisms of resistance
    - Explore pathogen informed deployment of resistance in agriculture

Acknowledgements

HIP
Holland Innovative Potato

HZPC
ROYAL HZPC GROUP

Averis

bejo

PEPSICO

Simplot

MEIJER
POTATO

*Solynta
hybrid potato breeding

Ministerie van Landbouw,
Natuur en Voedselkwaliteit

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- Isolde Bertram
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- Britt Karsenberg
- Pascalle Pronk
- Richard Visser

- Theo van der Lee
- Sander Grapendaal
- Jan van der Wolf

From soil biological fertility to potato health

How to combine agroecological farming practices in a field experiment?

Pasco C.[2], Bouchek K.[1], Kröner A.[1], Beduneau F.[1], Maestrali M.[1], Pirault J.[3], Andrivon D.[2], Puech C.[1]
[1] FN3PT/inov3PT ; [2] INRAE UMR IGEPP ; [3] INRAE UE La Motte

Study context

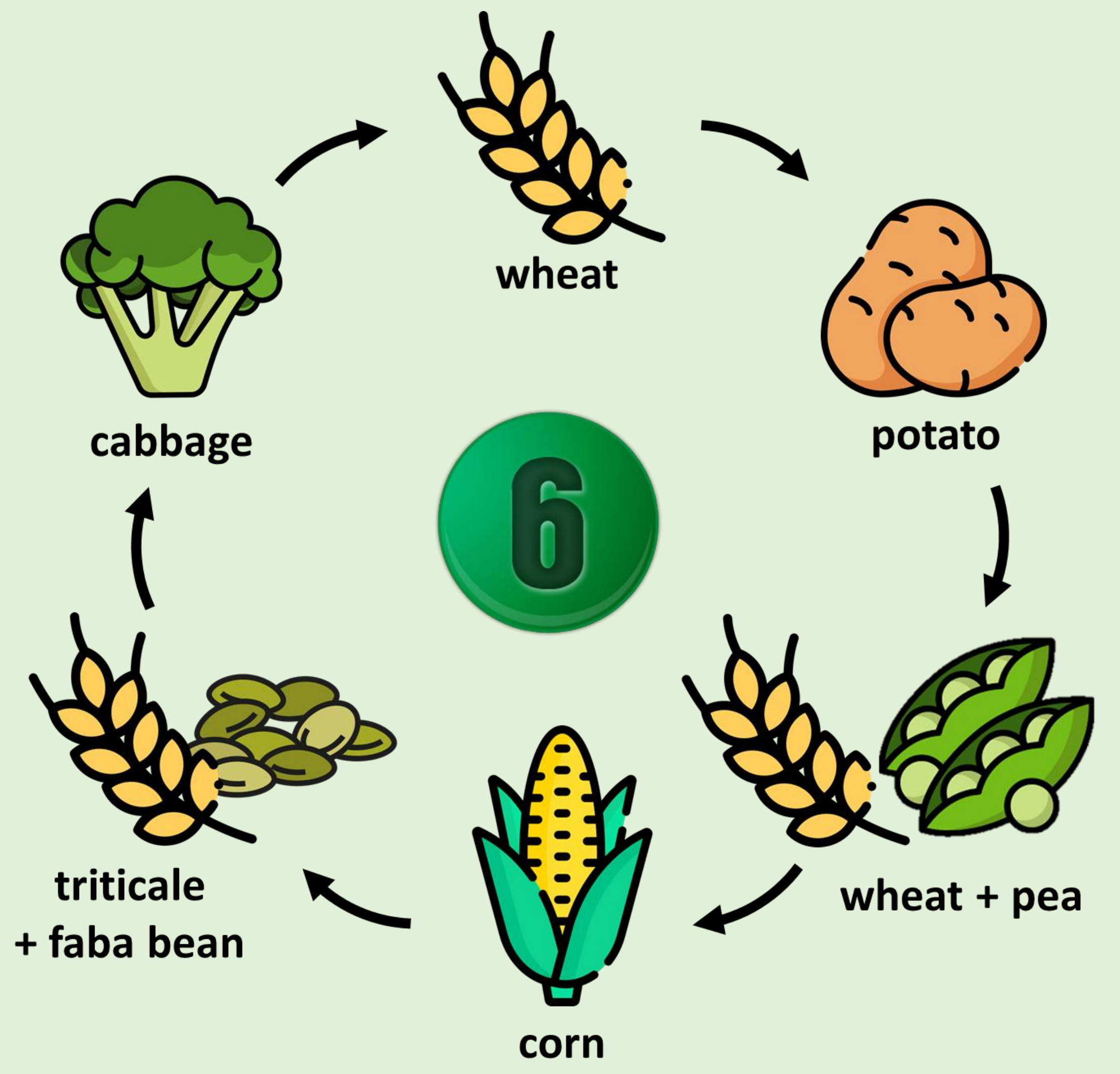
- 2018: 2 cropping systems are implemented in Brittany (France), based on 2 different tillage practices

Conventional tillage (annual ploughing) VS **Alternative tillage** (no ploughing)

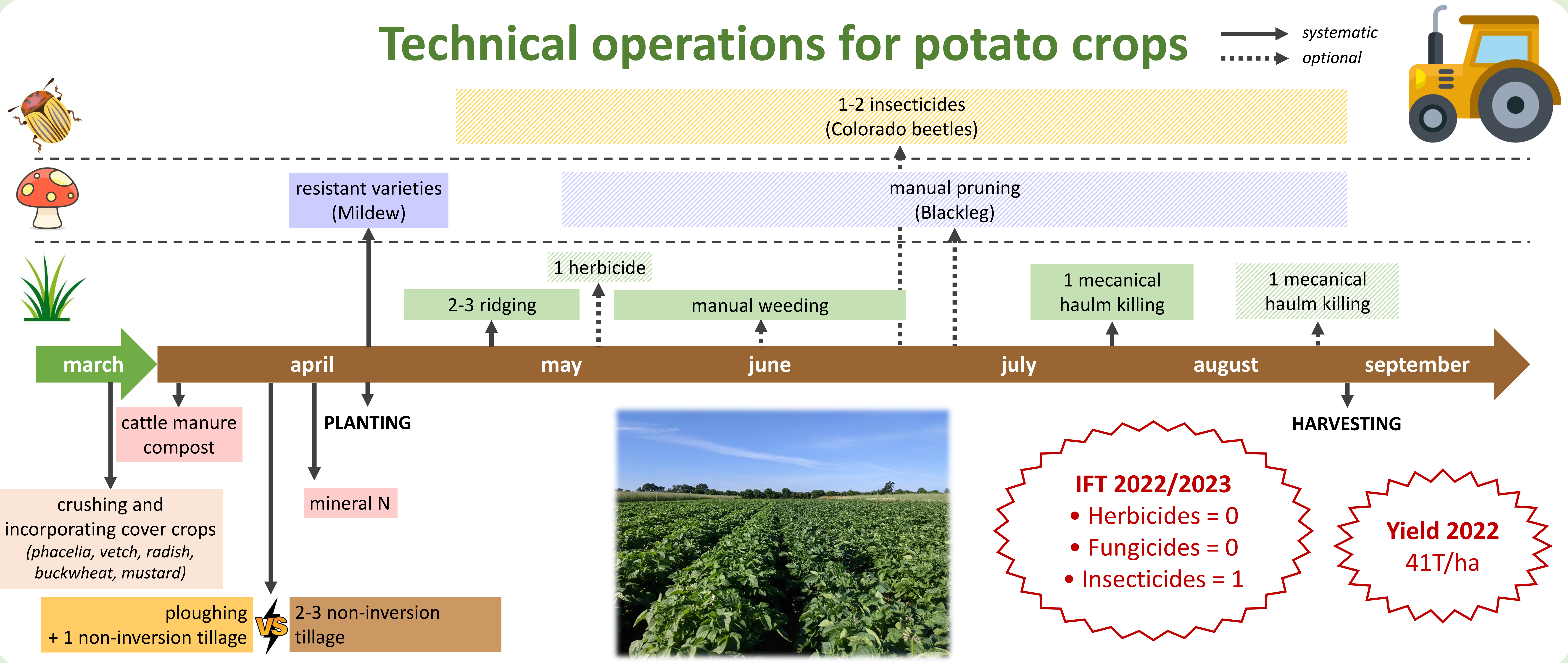
- 6 years crop rotation
- Very low amount of pesticides (only used as a last resort)
- Similar to farming production system (study field = 3ha)

Goal of this long-term experiment

To study the effect of tillage system on soil biological fertility and potato health



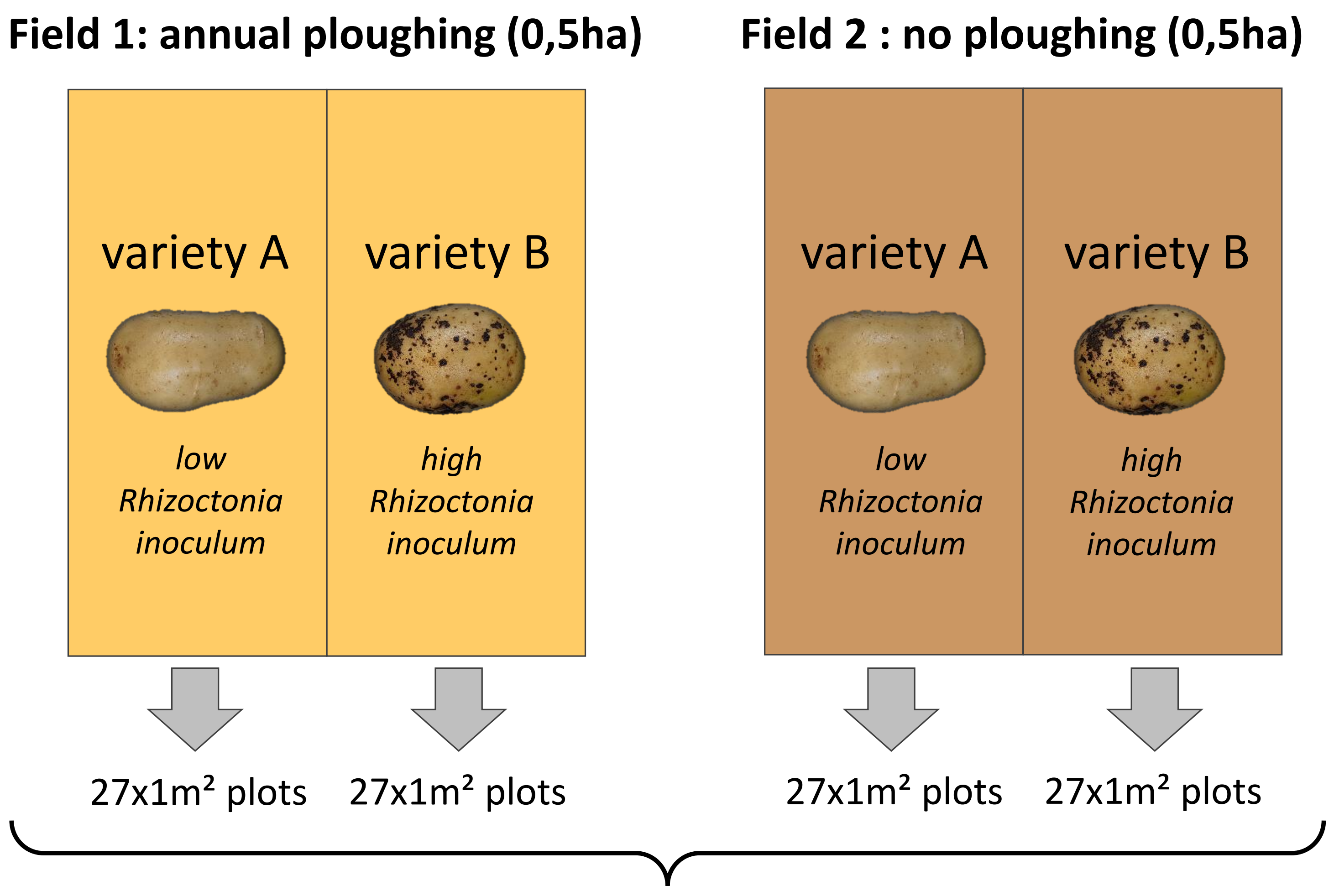
Technical operations for potato crops



IFT 2022/2023
- Herbicides = 0
- Fungicides = 0
- Insecticides = 1

Yield 2022
41T/ha

Experiment design 2022-2023-2024



Incidence and the severity of pests and diseases:

→ Weekly scoring of pests and airborne diseases : colorado beetles, aphids, wireworms, late blight, blackleg, viruses, early blight, black scurf.

→ At harvest, scoring of soilborne diseases and pests : common scab, black scurf, drycore, black dot, silver scurf and wireworms.

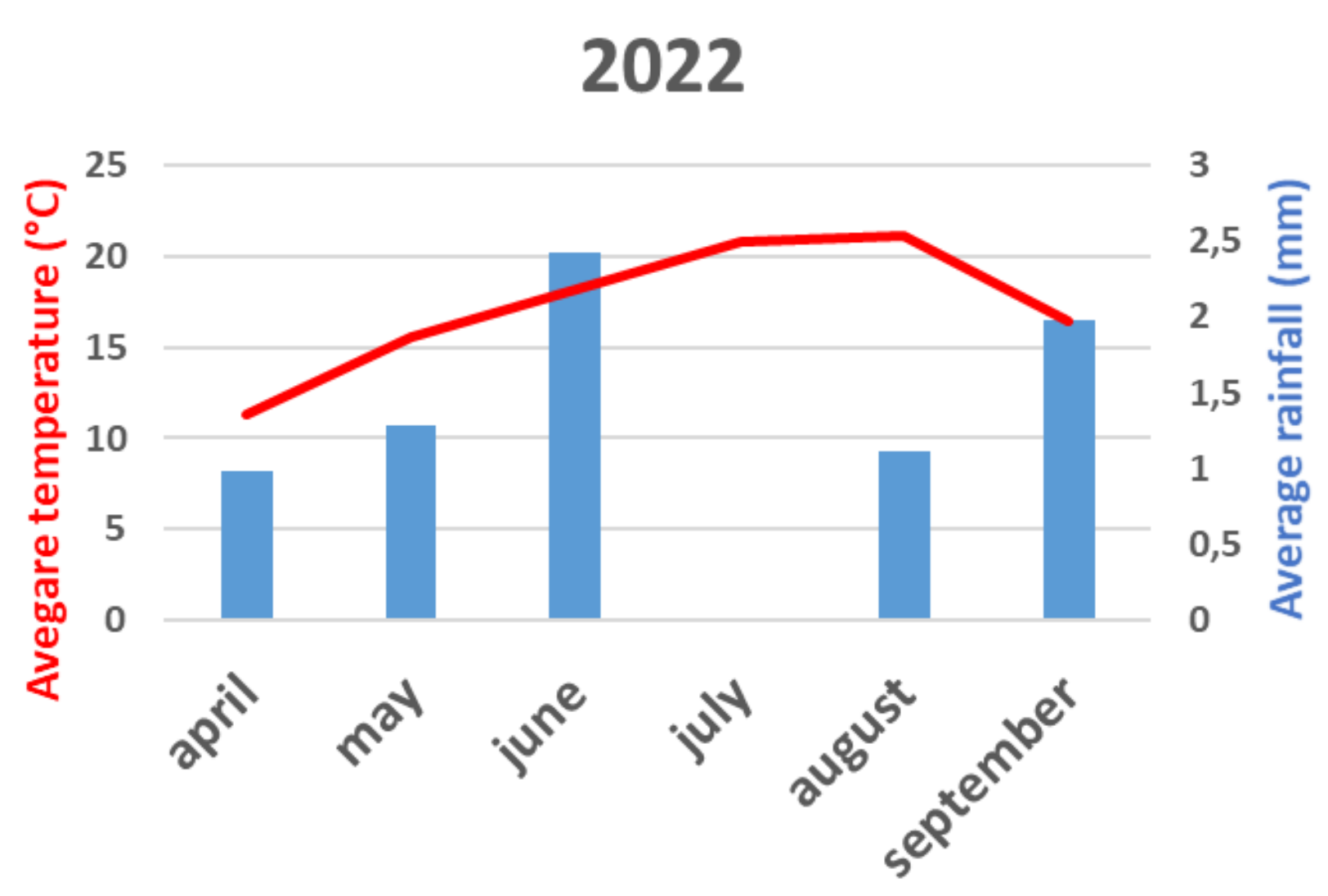
Soil biological fertility:

→ Abundance, diversity and activity of macrofauna (arthropods, earthworms), mesofauna (mites, springtails), microfauna (nematodes) and microorganisms

→ Soil stability

Main observations

Weather conditions



Ajouter le graphique 2023

Biological results

- Trend for a **higher regulation** of some potato diseases and pests **in the no ploughing field** (common scab, black scurf, colorado beetle)

- Trend for a **higher biological fertility in the no ploughing field** (earthworms, macrofauna, nematodes, microbial biomass, decomposition speed of organic matter, soil stability)

- **Interaction** with variety and initial inoculum on tubers (for black scurf)

- Results depend on the year and **must be confirmed**

EAPR Pathology and Pests Section • 3-6 September 2023 • Arras (France)

From soil biological fertility to potato health

How to assess soil biological quality?

Puech C.[1], Bouchek K.[1], **Kröner A.**[1], Béduneau F.[1], Maestrali M.[1], Andrivon D.[2], Pasco C.[2]
[1] FN3PT/inov3PT ; [2] INRAE UMR IGEPP ; [3] INRAE UE La Motte

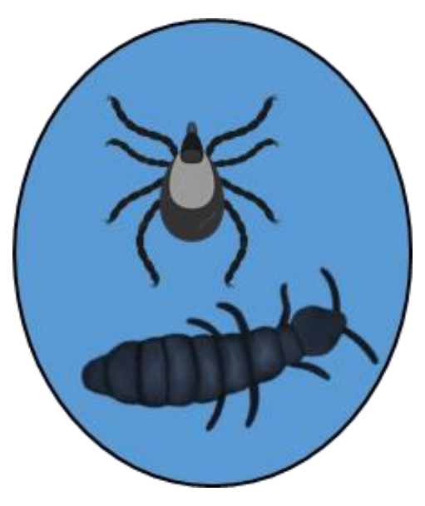
Soil community

- All organisms spending a part or their entire life in the soil
- Biodiversity reservoir : high biomass, high diversity, complex interactions
- Biological groups (classified by size, fauna only) :

Macrofauna
2mm-50mm

earthworms, carabid beetles, wireworms, etc.

Mesofauna
200µm-2mm

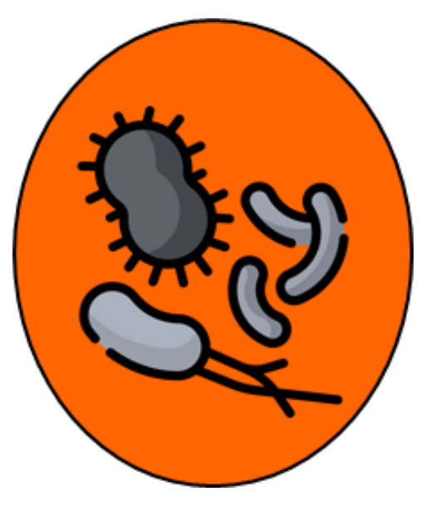


mites, springtails, etc.

Microfauna
5µm-200µm

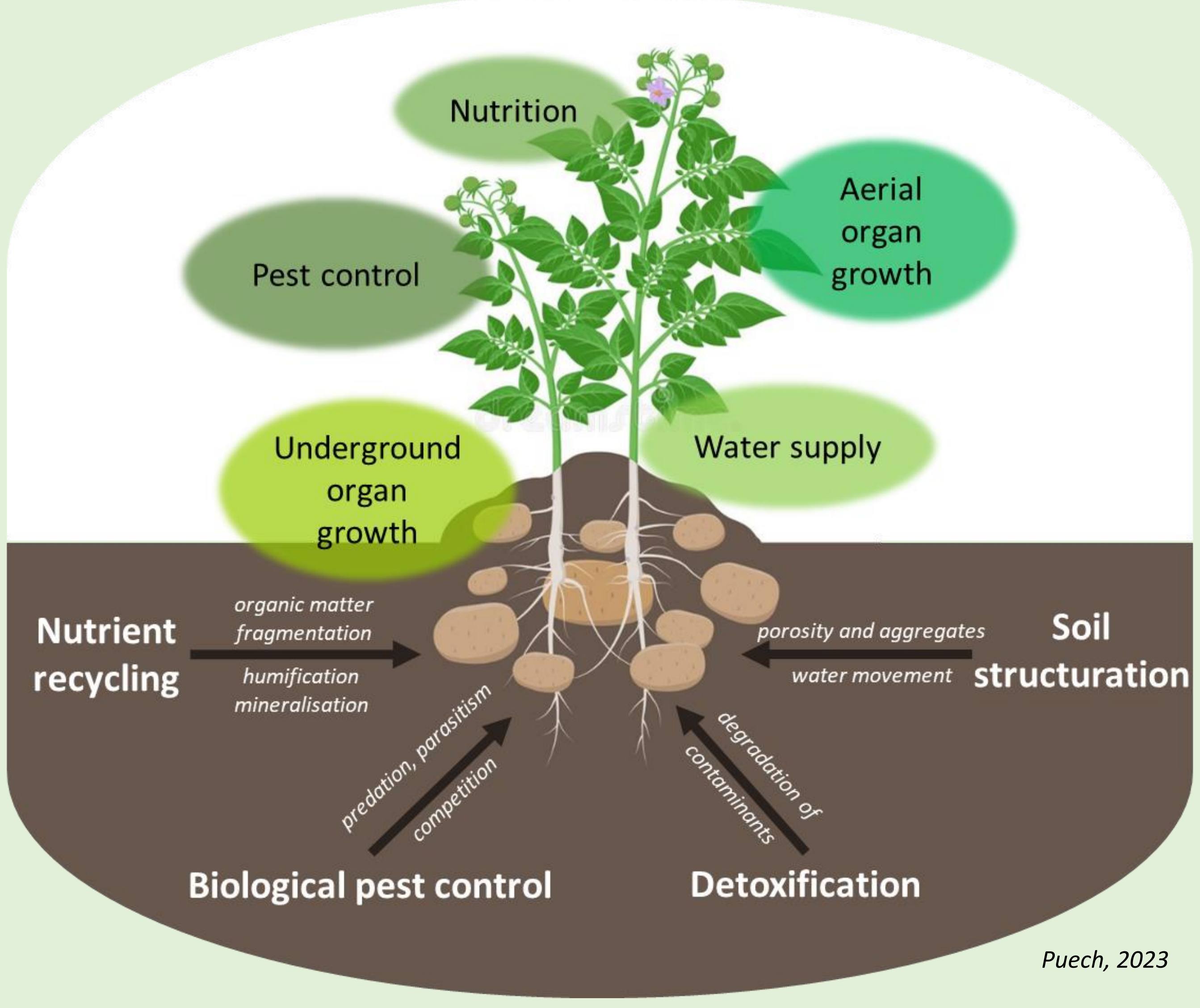
nematodes, protozoa, etc.

Micro-organisms
1µm-100µm



bacteria and fungi

→ A large set of ecological functions



Puech, 2023

Goals of this work

- To measure the **effects of tillage on soil biological quality** in a long-term experiment
- To identify **unexpensive and simple methods** for routine use in field trials and by producers

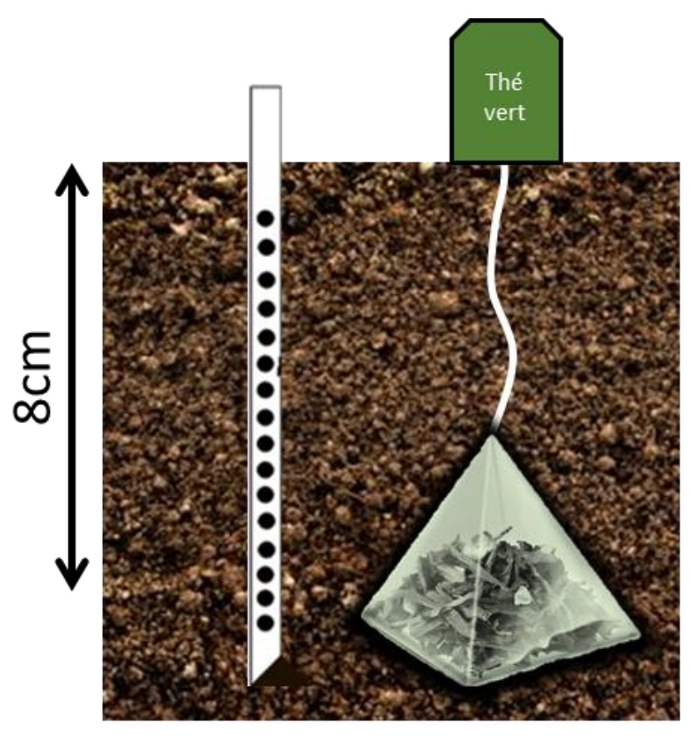
Which methods are used to assess soil biological quality

The underpants method

- To measure biological activity
- Cotton underpants are burried for 2 months
- Organic matter degradation is estimated

The tea bag & the bait lamina test

- To measure biological activity
- Tea bags and bait lamina are burried for 3 weeks or 3 months
- Organic matter degradation is estimated at different depths



The slake test

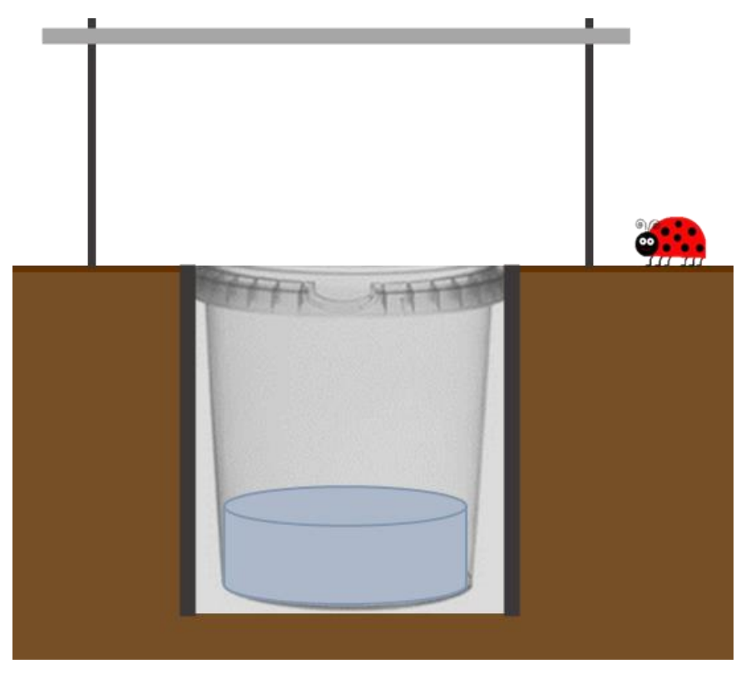
- To measure soil structural stability (indirectly related to biological fertility)
- With a soil stability kit or with pickle jars
- Soil aggregates are immersed in water and soil stability can be estimated

The earthworms spade test

- To measure abundance, biomass and diversity of earthworms
- A 20*20*25cm soil sample is extracted and crumbled
- Earthworms are counted and identified

The pitfall trap

- To measure abundance and diversity of ground-dwelling organisms
- A plastic pot is burried to capture organisms moving accross the soil
- Organisms are identified with a binocular magnifier



The Oostenbrink dish

- To measure abundance and diversity of free-living nematodes
- A soil sample is put on a sheet of filter paper and immersed in water
- Nematodes swim through the filter paper and are extracted and counted

+ Microbial analyses (made by a private laboratory) : microbial biomass, carbon and nitrogen mineralisation potential, organic matter fractionation

When is soil biological quality assessed?

3 possibilities

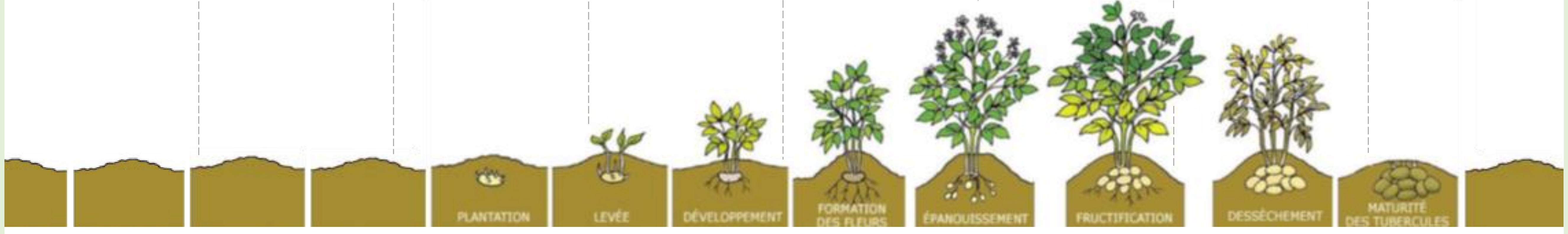
february-march
To evaluate the initial soil biological state of the field

april-august
To evaluate the soil biological state of the field during the growing season

october-november
To evaluate the final soil biological state of the field

In our long term experiment :

february march april may june july august september



✕ Earthworms spade test

✕ ✕ ✕ Pitfall traps

✕ ✕ Oostenbrink dish

✕ ✕ Slake test

✕ Sampling for microbial analyses

Bait lamina test

Underpants method + Tea bags

EAPR Pathology and Pests Section • 3-6 September 2023 • Arras (France)

inov3PT
SEED POTATO
FOR THE FUTURE

Design, experimentation and evaluation of an agroecological cropping system for seed potato production

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Comité Nord
Plants de Pommes de Terre

uneal coopérative

CONTEXT

Seed potato crops

Large diversity of pests and diseases

Progressive banning of pesticides

High tillage intensity

Need for a systemic approach

Cropping system scale

Consistent combination of alternative farming practices

Collective brainstorming

North of France
3 collaborators

Comité nord
(farmer association specialized in seed potatoes)
Uneal
(farmer cooperative)
inov3PT
(R&D team from a technical institute specialized in seed potatoes)

3 AIMS

① Reduce the use of pesticides by 50%

② Maintain economic results and quality of the production

③ Increase soil fertility

DESIGN

1 reference cropping system

= representative of the average practices implemented by farmers in the region
→ designed according to experts and to a survey with farmers

1 innovative cropping system

→ designed collectively during a workshop with farmers, agronomists and experts on potato diseases and pests management

EXPERIMENT

Experimental station
2020-2026

Reference + innovative systems
→ 12 micro-plots

Regular observations and measurements

EVALUATION

Field observations
↓
Indicators for goals achievement
(TFI, gross margin, % organic matter, etc.)

Multicriteria analyses
↓
Indicators for environmental, economical and social sustainability

REFERENCE CROPPING SYSTEM & MAIN ISSUES

Cover crop *(radish+clover)*	SEED POTATOES	*Cover crop* *(mustard+clover)*	MAIZE	WINTER WHEAT	*Cover crop* *(mustard+clover)*	BEETS	WINTER WHEAT
	Late blight Aphids – Virus Black scurf Scabs Weeds Potato regrowth Colorado beetles		Weeds Potato regrowth Wireworms	Weeds Aphids Yellow-brown rust Septoriosis Field mice		Weeds Aphids – Virus Cercosporiosis Rust Hares	Weeds Aphids Yellow-brown rust Septoriosis Field mice

INNOVATIVE CROPPING SYSTEM

	Cover crop *(vetch+faba bean+phacelia+radish) broadcast sowing*	SEED POTATOES	WINTER WHEAT	RAPE +clover +field bean	*Cover crop* *(clover)*	WINTER WHEAT direct seeding in clover	*Cover crop* *(clover+radish) broadcast sowing*	GRAIN MAIZE	WINTER WHEAT
fertilisation		Localised fertilisation	Decision tool Triple seeding rate on a strip	Decision tool		Decision tool Triple seeding rate on a strip		Localised fertilisation	Decision tool Triple seeding rate on a strip
Weeds		Ridging Spot treatment	Mechanical weeding Late seeding			Mechanical weeding		Mechanical weeding	Mechanical weeding Late seeding
Pests		Companion plants + Biocontrol (Aphids - Virus)	Late seeding + Decision rule (Aphids)	Pest monitoring + Early seeding + Early fertilisation (weevils, flea beetles) Mix with early variety (flea beetles)				Pest monitoring (Corn borer)	Late seeding + Decision rule (Aphids)
Diseases		Decision tool (Late blight) Brassicaceae in the previous crop (Black scurf) Resistant variety (Late blight + Virus)	Decision tool (diseases) Resistant variety (diseases)	Biocontrol (Sclerotinia) Resistant variety (Sclerotinia)		Decision tool (diseases) Resistant variety (diseases)			Decision tool (diseases) Resistant variety (diseases) Late seeding (Septoriosis)
Others	Mechanical destruction	Mechanical haulm killing		High yield variety	Mechanical destruction	Crushed straws	Mechanical destruction		Crushed straws

Localised treatments as much as possible

Optimisation of treatments spraying

Nesting boxes and perches (biocontrol)

Cover crops for nitrogen capture and soil structure improvement (legumes)

Extension and diversification of crop sequence

No tillage

1) Reduce the use of pesticides by 50%

2) Maintain economical results and quality of the production

3) Increase soil fertility

FN3PT
L'ENGAGEMENT POUR LE PLANT

EAPR Pathology and Pests Section
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RECHERCHE - DEVELOPPEMENT - INNOVATION
DES PRODUCTEURS DE PLANTS DE POMME DE TERRE